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The Engineer.

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VOL. CXLV.—No. 3769] LONDON: FRIDAY EVENING, APRIL 6, 1928 [PRICE ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department, Belvedere-road, Lambeth, S.E. 1, invites TENDERS for—

510 STEEL TYRES for LOCOMOTIVES, CARRIAGES and WAGONS.

Tenders due on the 20th April, 1928.

Forms of Tender obtainable from the above at a fee (which will not be returned) of 5s. for each schedule. 8178

Air Ministry. DIRECTORATE OF TECHNICAL DEVELOPMENT.

TEMPORARY DRAUGHTSMAN REQUIRED for work at No. 1 Stores Depot, Royal Air Force, Kidbrooke, S.E. 3.

Candidates must have knowledge of mechanical engineering practice and be capable of measuring up and making working drawings, isometric sketching and tracing. Some workshop experience and a capability for carrying out preliminary stress calculations is desirable.

Preference given to ex-Service men.

Salary up to 52s. a week plus Civil Service bonus (giving present total of 82s. a week) according to qualifications and experience.

Application should be made to the SECRETARY, Air Ministry, Adastral House, Kingsway, W.C. 2, not later than 18th April, 1928. 8189

Assistant Engineer REQUIRED by the LAGOS TOWN COUNCIL, NIGERIA, for two tours of 12 to 18 months' service, with prospect of extension. Salary £480 for the first three years, then £510, rising by annual increments to £720 a year. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, aged 25 to 35, should be A.M.I.C.E. or hold the Testamur of the Institution of Municipal and County Engineers or other approved Diploma. Must have had a good office training in a Municipal Engineer's office, be good surveyors and have had experience in Drainage, Town Planning and other Municipal Works. A knowledge of valuation and assessment of properties will be an advantage.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/554. 8190

Assistant Engineers REQUIRED for the Railway Department of Nigeria for a tour of 12 to 18 months' service, with prospect of extension. Salary £480, rising to £920 a year. Outfit allowance of £60 on first appointment. Free quarters passages, and liberal leave on full salary. Candidates, aged 23 to 35, should either possess an engineering degree of a recognised University or should have passed Sections "A" and "B" of the Associate Membership examination of the Institution of Civil Engineers. They should also have had 3 or 4 years' regular training as a Civil Engineer, preferably on railway works.—Apply at once by letter, stating age, particulars of qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/15394. 8191

Ministry of Transport. APPLICATIONS are INVITED for APPOINTMENTS as ASSISTANT ENGINEER in the Divisional Offices of the Roads Department of the Ministry of Transport at a commencing salary of £250 per annum on the scale £250-15-450 plus bonus, which is subject to revision according to the cost-of-living index figure. The present bonus on £250 is £111 8s, subject to revision on September 1st. Assistant Engineers are eligible for promotion to higher posts. The Divisional Offices are situated in London, Edinburgh, Leeds, Birmingham, Exeter and Cardiff, and selected candidates will be liable to serve at any of these towns. The appointments will be on an established pensionable basis and will be subject to a probationary period of one year.

Candidates should be Chartered Civil Engineers or should hold some equivalent professional qualification. Previous experience in road and bridge construction is essential and a knowledge of Highway Authorities' procedure is desirable. Candidates should be not more than 35 years of age and, other things being equal, preference will be given to men who have served in His Majesty's Forces.

Forms of application can be obtained from the ESTABLISHMENT OFFICER, Ministry of Transport, 6, Whitehall-gardens, S.W. 1. Applications can only be received on the recognised forms, and should reach the Ministry of Transport on or before the 16th April, 1928. 8169

University of Liverpool.

FACULTY OF ENGINEERING.

DEAN: Professor C. O. BANNISTER, M.Eng., Assoc. R.S.M., F.I.C., M. Inst. M.M.

Prospectus and full particulars may be obtained on application to the Registrar of Courses designed for Students desiring to qualify as Mechanical, Electrical, Civil or Marine Engineers, as Naval Architects or as Metallurgists and Metallurgical Engineers. 8171

Benares Hindu University. ENGINEERING COLLEGE.

WANTED, a UNIVERSITY PROFESSOR of MECHANICAL ENGINEERING. Salary Rs. 1000 per month, rising by annual increments of Rs. 50 to Rs. 1500 per month.

Only University Graduates with Honours in Engineering and with at least 10 years' teaching experience and who are, at the same time, first-class practical men, need apply.

The gentleman appointed will have to sign an agreement to serve the University for at least five years.

The Engineering College is one of four at present existing on the University grounds, which occupy a pleasant site and cover an area of over 2 square miles.

The College was founded in April, 1919, and is now one of the largest Engineering Colleges in India. The workshop and laboratories are large and well equipped and further extension is now contemplated. The number of students at present in the College is about 450. The staff and students at present living on the site number over 2000, and the electric supply for all lights, fans and water is provided by the Engineering College.

Applications should reach the office of The Engineer, Box No. P4360, 33, Norfolk-street, Strand, London, W.C. 2, before May 1st, 1928.

The undersigned will be in England and interview selected candidates in May by special appointment.

CHARLES A. KING,
Principal, Engineering College, Benares Hindu University (India). P4360

The Engineer

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PUBLIC NOTICES

Armstrong College,

NEWCASTLE-UPON-TYNE.

(IN THE UNIVERSITY OF DURHAM.)

COURSES for the PASS DEGREE of B.Sc. and the HONOURS DEGREE of B.SC. in MECHANICAL, MARINE, CIVIL or ELECTRICAL ENGINEERING, MINING, METALLURGY, or NAVAL ARCHITECTURE. The curricula of the Pass Degree and the Honours Degree normally occupy periods of three and four years respectively, but candidates presenting evidence of sufficient previous training may be allowed to proceed to either Degree after two years' residence.

The engineering laboratories have recently been extended, and all Departments are equipped for advanced tutorial and research work.

Full particulars of the Courses may be had on application to

THE REGISTRAR,
Armstrong College,
7059 Newcastle-upon-Tyne.

Borough Polytechnic Institute. LONDON, S.E. 1.

HEAD OF DEPARTMENT OF MECHANICAL AND STRUCTURAL ENGINEERING.

The Governors invite APPLICATIONS for the POST of HEAD of the MECHANICAL and STRUCTURAL ENGINEERING DEPARTMENT, rendered vacant by the retirement of Mr. G. E. Draycott. The remuneration will be in accordance with the approved London salary scales (£675-£25-£830 at present). Full-time service is required. Particulars of the appointment and forms of application may be obtained by sending stamped addressed foolscap envelope to the undersigned.

J. W. BISPHAM,
8127 Principal.

PUBLIC NOTICES

University College of South WALES AND MONMOUTHSHIRE.
COLEG PRIFATHROFAOL DEHEUDIR CYMRU A MYNWY.

The Council of the College invites APPLICATIONS for the POST of PROFESSOR of ENGINEERING. Salary £1000 per annum.

Candidates should submit the names of three referees; they may also, if they so desire, send copies of testimonials. One hundred copies of applications and any testimonials submitted must be received, on or before April 28, 1928, by the undersigned, from whom further particulars may be obtained.

D. J. A. BROWN,
Registrar.
University College, Cardiff,
March 23, 1928. 8164

County Borough of Southend-on-Sea. EASTERN VALLEY PUMPING STATION.
TO MAKERS OF PUMPS.

The Corporation are prepared to receive TENDERS for the SUPPLY of ONE ELECTRICALLY DRIVEN DIRECT-COUPLED CENTRIFUGAL PUMPING SET capable of pumping 270 cubic feet of unscreened sewage per minute through an existing 15in. diameter cast iron rising main, 1555ft. in length, against a static head of 16ft.

The motors should be wound to give normal output at 430 volts direct current.

Tenderers will be required to submit prices for manufacture, delivery and installation of the pumping set on foundations prepared by the Corporation, and the price is to include all necessary cast iron valves and pipes.

A plan of existing pumping station and general conditions may be inspected and copies of form of Tender and specification obtained on and after April 2nd, 1928, on application to Mr. Robt. H. Dyer, Borough Engineer and Surveyor, on payment of a deposit of £2, which will be refunded on receipt of a bona fide Tender and the return of all loaned documents.

Sealed Tenders, addressed to the undersigned and endorsed "Pumping Set, Eastern Valley Station," are to be delivered to this office on or before Twelve Noon, April 30th, 1928.

The Corporation do not bind themselves to accept the lowest or any Tender.

H. J. WORWOOD,
Town Clerk.
Municipal Buildings,
Clarence-road, Southend-on-Sea,
22nd March, 1928. 8089

PUBLIC NOTICES

The Manchester Steam Users' ASSOCIATION.

The ANNUAL GENERAL MEETING of the MEMBERS was held in the Board Room of the Association, at their Offices, 9, Mount-street, Manchester, on Tuesday, March 27th, Harold Lee, Esq., J.P. (Manchester), President, in the chair, when the following resolutions were adopted:—

Moved by the Chairman, seconded by J. T. Browne, Esq., Pendlebury (Vice-President), and resolved:—

"That the Report of the Committee of Management to the Subscribers, together with the Financial Statement, for the year 1927, be and is hereby approved and adopted."

Moved by F. R. Willcocks, Esq. (Wilson Brothers Bobbin Co., Ltd., Garston), seconded by R. C. Macdonald, Esq. (South Metropolitan Gas Co., London), and resolved:—

"That the thanks of the Association are due and are hereby presented to the Committee of Management for their past services, and that the following gentlemen be elected the Committee for the ensuing year, with power to add to their number:—

COMMITTEE OF MANAGEMENT.
Harold Lee, Esq., J.P., Manchester.
A. Norman Dugdale, Esq., J.P., Blackburn.
Jas. Stanley Addison, Esq., London.
J. T. Browne, Esq., Pendlebury.
Charles W. Crossley, Esq., J.P., Halifax.
G. Leonard Bolden, Esq., Manchester.
C. J. G. MacGuckin, Esq., Openshaw."

Moved by T. Hutchinson, Esq. (Fine Cotton Spinners' and Doublers' Association, Ltd., Manchester), seconded by E. Turnbull, Esq. (Messrs. Tate and Lyle, Ltd., Liverpool), and resolved:—

"That Messrs. F. W. Poppiewell and Son, Chartered Accountants, Manchester, be appointed Auditors of the Association's accounts for the year 1928."

JAMES PARR,
Secretary.
9, Mount-street, Albert-square, Manchester,
30th March, 1928. 8161

The Institution of Structural ENGINEERS.

DORMAN-LONG TRAVELLING SCHOLARSHIP.

The Institution is this year presenting the above-named Travelling Scholarship, value £300, and Gold Medal. The Scholarship is awarded for a Competition in the Design of a Steel-frame Structure. All members (in any class) of the Institution are eligible to compete. Closing date for entries, May 7th. Syllabus and full particulars from the undersigned.

By Order of the Council,
MAURICE G. KIDDY,
Secretary of the Institution.
10, Upper Belgrave-street, S.W. 1,
3rd April, 1928. 8188

Borough of Bridlington. DRIVING ADITS AT THE WATERWORKS.

The Town Council invite TENDERS for the DRIVING or EXTENDING of EXISTING ADITS at the Waterworks Pumping Station.

The conditions of contract may be inspected and copies of the specification and forms of Tender obtained at the office of Mr. W. Thompson, the Waterworks Engineer, Marton-road, Bridlington.

Sealed Tenders, endorsed "Tender for Adits," must be delivered at my office by not later than Noon on Thursday, the 12th day of April, 1928.

The Council do not bind themselves to accept the lowest or any Tender.

GEORGE MELVIN,
Town Clerk.
Town Hall, Bridlington,
30th March, 1928. 8162

Chorleywood Urban District COUNCIL.
SEWERAGE.

TENDERS are INVITED for LAYING SEWERS, including the CONSTRUCTION of MANHOLES, FLUSHING TANKS and SEWAGE DISPOSAL WORKS.

Plans, specification and general conditions may be seen at the office of the Surveyor to the Chorleywood Urban District Council at Chorleywood or at the office of the Engineer, Mr. A. P. I. Cotterell, of 94, Victoria-street, Westminster, during the hours of 9.30 a.m. to 11.30 a.m. and 3 p.m. to 5 p.m.

Copies of the bills of quantities and form of Tender, &c., may be obtained from the Quantity Surveyor, Mr. C. W. Latter, of 44, Bedford-row, W.C., by intending contractors on the payment to him of the sum of £5 5s., which will be returned on receipt of a bona fide Tender and all other documents supplied. All applications for the bills of quantities are to be made to the Quantity Surveyor on or before the 10th April, 1928, after which no further applications will be received.

Tenders, on the form provided, enclosed in sealed envelopes, must be delivered, accompanied by the priced bills of quantities, to the undersigned at Bank Chambers, Chesham, Bucks, and endorsed "Sewerage," not later than Twelve Noon on 30th April, 1928.

Contractors will be required to provide securities for performance of the contract under Section 174 (4) of the Public Health Acts, 1875.

The Council do not undertake to accept the lowest or any Tender.

By Order,
GEORGE S. SCOTT,
Clerk to the Chorleywood Urban District Council.
24th March, 1928. 8097

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PUBLIC NOTICES

Liverpool Corporation Water-Works.

VYRNWY SUPPLY.
THIRD INSTALMENT.
CONTRACT NO. 6.
PIPE LAYING.

The Water Committee of the Liverpool Corporation are prepared to receive TENDERS from competent persons willing to enter into a contract for the LAYING of STEEL PIPES of 42in. internal diameter and other Ancillary Works, as follows :—

From Ashton's Cross to Beeston Moss, in the County of Chester, for a distance of about 5¼ miles.

The plans and sections may be inspected and copies of the specification and form of Tender obtained at the Water Engineer's Office, Alexandra Buildings, 55, Dale-street, Liverpool, upon payment of the sum of Five Guineas, which amount will be returned upon receipt of a bona fide Tender.

Tenders, endorsed "Tender for Pipe Laying," are to be sent through the post in a sealed envelope, addressed to "The Town Clerk, Municipal Buildings, Liverpool," so as to be delivered not later than Twelve o'clock Noon on Monday, the 23rd April, 1928.

The Water Committee do not bind themselves to accept the lowest or any other Tender.

WALTER MOON,
Town Clerk.

Municipal Buildings, Liverpool,
April, 1928. 8185

Metropolitan Borough of St. Pancras.

BATHS DEPARTMENT.

The St. Pancras Borough Council invite TENDERS for the SUPPLY and ERECTION of ONE LANCASHIRE BOILER at the Whitfield-street Baths.

Plans can be seen and specification obtained at the offices of the Electricity Department, 57, Prattstreet, Camden Town, N.W. 1, on the payment of One Pound, which will be returned on the receipt of a bona fide Tender.

Tenders to be sent in on or before Noon on Friday, May 11th, 1928.

F. V. CREED,
Town Clerk.

Town Hall,
Pancras-road, N.W. 1. 8168

The Assam - Bengal Railway

COMPANY, Limited, is prepared to receive TENDERS for :—

STRUCTURAL STEEL WORK, GALVANISED WORK, &c., FOR ENGINE ERECTING SHOP.

Specifications and Tender forms may be obtained at the offices of the Company, Bishopsgate House, 80, Bishopsgate, E.C. 2.

A fee of £1 1s. is charged for each specification, which cannot under any circumstances be returned.

Drawings may be had, at the cost of the tenderer, by application to Messrs. Hodges Bennett and Co., Ltd., 78, Queen Victoria-street, E.C. 4.

Tenders must be delivered at the Company's offices not later than Noon on Wednesday, the 25th April, 1928.

The Directors do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
THOS. C. BRETT,
Secretary.

3rd April, 1928. 8174

28.3.28.

The North British Aluminium COMPANY, LTD.

LOCHABER WATER POWER.
SPECIFICATION NO. 104.

The North British Aluminium Co., Ltd., is prepared to receive TENDERS for the CONSTRUCTION, DELIVERY and ERECTION near Fort William, Inverness-shire, of :—

STRUCTURAL STEEL WORK for POWER-HOUSE and FACTORY BUILDINGS.

Copies of the specification, conditions of contract and forms of Tender may be obtained on and after 5th April, 1928, at the Company's offices, Adelaide House, King William-street, London, E.C. 4.

Sealed Tenders, endorsed :—
Lochaber Water Power,
Specification No. 104,
Tender for Structural Steel Work,
must be addressed to the SECRETARY and delivered at the Company's offices not later than 10 a.m. on Tuesday, 24th April, 1928.

The Company does not bind itself to accept the lowest or any Tender.

Preference will be given to contractors on the King's Roll. 8122

Civil Service Commission.

POSITION VACANT—CHIEF EXAMINER OF APPLICATIONS FOR PATENTS OF INVENTIONS.

The Civil Service Commissioners invite APPLICATIONS for the PERMANENT and PENSIONABLE POST of CHIEF EXAMINER of APPLICATIONS for PATENTS of INVENTIONS in the Department of Industry and Commerce. Salary scale :—Married man, £400-£500 ; unmarried man or woman, £300-£400 a year plus cost-of-living bonus in each case. At present the bonus on £300 is £140 17s. and on £400 is £168 11s. Age limits 35 to 50 years. Main qualifications are good general education, exceptional initiative, judgment and organising ability. Preference will be given to applicants with training and experience in Mechanical, Civil or Electrical Engineering or Industrial Chemistry. Latest date for receiving applications 14th April, 1928.—Application forms and particulars may be obtained from the SECRETARY, Civil Service Commission, 35, St. Stephen's Green, Dublin, C. 2.

9/8.3895. W. H. Co. 8166

Egyptian Government.

PUBLIC WORKS MINISTRY.
NOTICE.

The Egyptian Public Works Ministry (Irrigation Projects Department) REQUIRES an expert DESIGNER for Works in Masonry, Steel and Reinforced Concrete.

Salary Nine Hundred Egyptian Pounds per annum.

Applicants must hold a University Degree in Civil Engineering and they must have had at least eight years' practical experience of constructional work with some well-known firm of engineers or contractors.

Applications, together with degrees and testimonials, should be addressed to the UNDER-SECRETARY OF STATE, Public Works Ministry, Cairo, before 1st May, 1928. 8170

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED by Firm in South of England, First-class RATE FIXER for up-to-date plant engaged on manufacture of light, accurate and special machines. Applications will be considered only from men who have held similar positions and are fully acquainted with latest practice. Copies of testimonials to be sent and details of experience and salary required to be stated. Information given treated in confidence.—Address, 8181, The Engineer Office. 8181 A

WANTED for England, WORKS ENGINEER, with good experience in the erection of wet process Cement Works Machinery and its maintenance. Previous experience in this class of work essential. Applications, giving full particulars of age, qualifications and particulars, with dates of appointments previously held, should be received by the 11th April.—Address, P4337, The Engineer Office. P4337 A

WANTED in London, YOUNG ENGINEER, with good technical education and not less than five years' practical experience in Design and Operation of Metallurgical Equipment.—Address, 8180, The Engineer Office. 8180 A

WANTED, APPRENTICE DRAUGHTSMAN as Improver, to carry out neat sketches of pipe line arrangements in furnace and boiler design.

FILMA OIL BURNERS, Limited, 68, Victoria-street, London, S.W. 1. 8109 A

The position of Works Manager is vacant in a large Engineering Works in the Midlands, employing over 4,000 Work-people.

Applications to fill this position are invited.

Address replies

A. c/o SIR CHARLES HIGHAM,
IMPERIAL HOUSE, KINGSWAY, LONDON.

SITUATIONS OPEN (continued)

A FULLY TRAINED and EXPERIENCED REFRIGERATION ENGINEER, who is also a competent and experienced Salesman, is REQUIRED for the London Office of a well-known Continental Engineering Firm to organise and Take Charge of the Sale of their Household Refrigerators among households, hotels, cold storages, &c., in this country. Applicants should possess intimate knowledge of the market in this country and must give full particulars of age, technical and sales training, qualifications and experience, salary required and when free commence duties.

Address,
P4369 A P4369, The Engineer Office.

AN Opportunity Presents Itself for the APPOINTMENT of a well-educated MARINE ENGINEER with Diesel Engine experience as a SALESMAN calling on Superintendent Engineers, &c. Applicants for this post are invited to state full particulars of experience, &c. Good salary and expenses to suitable applicant.

Write, Box No. 1, c/o Walter Hill, 67, Southampton-row, W.C. 1. P4367 A

ENGINEERING MERCHANTS, London, REQUIRE capable MAN to ASSIST DIRECTOR ; competent buyer and salesman, knowledge Tube Trade preferable. Only keen progressive men need apply. State age, experience, salary required.—Address, P4364, The Engineer Office. P4364 A

RATE-FIXING.—A GOOD OPENING OCCURS for a keen, intelligent YOUNG ENGINEER, age 18-25, in the Rate-fixing Department of a large, up-to-date firm of Electrical Engineers. Preference will be given to applicants possessing similar experience.—Address, giving precise details of experience, age and salary required, &c., 8186, The Engineer Office. 8186 A

WANTED, High-class PRECISION TOOL DRAUGHTSMAN, with a mathematical mind versed in organising technical data in tables and graphs, to supervise operation, planning and time study for the MANUFACTURE of MACHINES and scientific apparatus, including lenses.—TAYLOR-HOBSON, LTD., LEICESTER. 8192 A

WANTED, JIG and TOOL DRAUGHTSMAN, with experience in Special Machine Design. Notts. district.—Write, stating full experience, age, and wage required, to Box W. 214, Willing's, 86, Strand, W.C. 2. 8175 A

DRAUGHTSMAN for Machinery Foundations and General Civil Engineering Work REQUIRED IMMEDIATELY for Engineer's Office in Westminster. State experience, age, salary required.—Address, P4370, The Engineer Office. P4370 A

DRAUGHTSMAN WANTED, Glasgow District, experienced in all types of conveyors, Experience of underground conveying or rope-ways an advantage. First-class man only need apply. Reply, stating age, experience, salary required, and when at liberty.—Address, 8193, The Engineer Office. 8193 A

DRAUGHTSMAN, with Experience in Fan Detail Work, by London firm.—Write, stating age, experience and salary required, to Box 130, c.o. Mather and Crowther, Ltd., 10-13, New Bridge-street, E.C. 4. 8179 A

EXPERIENCED DRAUGHTSMEN WANTED in the Midlands for Steam Turbine Details. State age, training, experience, salary, and when free.—Address, 8187, The Engineer Office. 8187 A

JUNIOR TOOL DRAUGHTSMAN, with Shop and O.D. experience in Press Tools, Jigs and Gauges, for small components. WANTED by large East Anglian firm. State age, experience, and salary required.—Address, 8183, The Engineer Office. 8183 A

CLERK REQUIRED by Constructional Engineers in London, capable of reading drawings and taking out quantities for estimating.—Address, stating age, experience, and salary required, P4365, The Engineer Office. P4365 A

REQUIRED, Experienced COST CLERK, Accustomed to Foundry and Machine Shop Costing Systems, Piece Rate Fixing and Analysis of same ; must also possess a good commercial experience.

Applicant must have had engineering training and experience and be able to assist manager in works administration.

State age, experience, and salary required and if at present engaged.

Address, 8182, The Engineer Office. 8182 A

REQUIRED by a European Firm of Structural and General Engineers in India, an ASSISTANT FOREMAN in their Structural Department. Applicants must have experience in Template Making and be accustomed to Bridge, Roof and General Structural Work ; must be a bachelor and not more than 26 years of age.—Apply, stating age and full particulars of experience, to Z.X. 489, care Deacon's Advertising Agency, Fenchurch-avenue, E.C. 3. 8176 A

SITUATIONS WANTED

ADVERTISER (41) REQUIRES POSITION, Specialist in organisation and production, gen. eng., railway work, constructional and contractors ; wide exp. managerial positions.—Address, P4368, The Engineer Office. P4368 B

BOILERMAKER, General All-round Practical and technical man, with sound experience of locomotive boilers and boilers of all types, able to design and construct boilers of any class, and accustomed to general repairs to the existing ones throughout ; having also extensive experience of general constructional work, tanks of every description and well advanced with general engineering work ; has been employed on large railways in India, Persia and South America, now employed with the Chinese Government Railways employed as boiler shop foreman and chief boiler inspector, taking charge of over 1000 Chinese workmen, will be disengaged in November and DESIRES POST in any part of the globe. Highest references ; single man, age 38, and enjoys splendid health.—Address, P4310, The Engineer Office. P4310 B

CIVIL ENGINEER (M. Inst. C.E.), 46, DESIRES APPOINTMENT as Engineer or Contractors' Agent at home/abroad ; 22 years' experience at home, in the Colonies, and abroad ; accustomed to handle native labour and control staff. Has been in full charge of large railway and other construction work. Fluent Spanish and Portuguese.—Address, P4348, The Engineer Office. P4348 B

PARTNERSHIPS

IF YOU ARE SEEKING
A PARTNER or PARTNERSHIP
or wish to buy or sell a
BUSINESS or WORKS
Write :
WHEATLEY KIRK, PRICE & CO.,
46, Watling Street,
London, E.C. 4.
Established over 75 years.

STEAM ENGINEERING COMPANY Will ADMIT PARTNER with £1250 capital to resuscitate and manage central organisation of Sales Department, old-established business, well-known fuel-saving appliances.—Address, P4371, The Engineer Office. P4371 C

EDUCATIONAL

Correspondence Courses

OF PREPARATION FOR THE
Examinations of the
INST. OF CIVIL ENGINEERS,
INST. OF MECHANICAL ENGRS.,
INST. OF STRUCTURAL ENGRS.,
UNIVERSITY OF LONDON, &c
are personally conducted by
Mr. Trevor W. Phillips,
B.Sc., Honours, Engineering, London University Assoc. M. Inst. C.E., A.M.I. Struct. E., M.R.S.I., F.R.S.A., Chartered Civil Engineer, &c.
For full particulars and advice, apply to :—9-11, TRAFFORD CHAMBERS, 58, SOUTH JOHN ST., LIVERPOOL. (Tel. Bank 1113). LONDON OFFICE :—63, CHANCERY LANE, W.C. 2. Ex.

ENGINEERS, Do You Want a Good Job ? "THE ENGINEER'S GUIDE TO SUCCESS" will tell you how we have helped over 10,000 Engineers, and we can help YOU. Send for free copy to-day. 40 Engineering Courses arranged for home study fully described. Preparation for A.M.I. Mech. E. and all Engineering Exams. Tuition until pass. No time limit. Advice free.—THE TECHNOLOGICAL INSTITUTE, Est. 1918, 76, Temple Bar House, London, E.C. 4. 7710 E

ENGINEERS—£500 a Year Awaits You.—Prof. A. M. LOW shows HOW in "ENGINEERING OPPORTUNITIES." This free 70-pp. book shows the easiest way to pass A.M.I. Mech. E., A.M.I.E.E., A.M.I.A.E., A.M.I.C.E., &c., Exams. We alone can guarantee "NO PASS—NO FEE." Courses in all branches. Write now, state subject or exam.—BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY, 22, Shakespeare House, Leicester-square, London. P4361 E

TO ENGINEERS GOING ABROAD AND OTHERS.—Thorough PRACTICAL INSTRUCTION GIVEN in SURVEYING and LEVELLING.—Address, E. MOUL, Hollybank, Woking. P4302 E

PATENTS

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For continuation of For Sale Advertisements see page 3.

A Seven-Day Journal

A Notable Jubilee.

ON Friday last a notable jubilee was celebrated by a splendid banquet given by the directors of Crompton Parkinson, Ltd., to Colonel R. E. Crompton to commemorate the founding of Crompton and Co. in 1878, and to do honour to one to whom the electrical industry owes so much. Mr. A. A. Campbell Swinton was in the chair, and a very large number of engineers well known in the electrical world were present. The toast of the evening was proposed from the chair, and was seconded by Mr. S. Z. de Ferranti, both speeches naturally being full of reminiscences, some amusing enough to keep the company in high spirits. When the Colonel rose to respond, there was prolonged cheering, and "For he's a jolly good fellow" was sung, not as one of the most melancholy songs in the British repertoire, but as if everybody felt it and wished the old man to know that they felt it. Colonel Crompton, in his reply, touched upon some of his experiences, but his speech was most notable for the very generous appreciation he showed for the work of others, particularly those who had worked with him at Cromptons. He protested that he had become an electrical engineer by chance. He had made a success of road locomotion in India, and came back to England believing that his future and his fortune were awaiting him in that line. His hopes, however, were not fulfilled, and his attention being directed to electrical engineering by the Exhibition of 1881, he became interested in electrical lighting, invented arc lamps, and, with Bürgin, the well-known dynamo which is known by their joint names, and laid the foundation of a manufacturing industry. Of all that he has done for electrical engineering it is impossible to speak in this place, but, as despite his eighty-three years, he is as active minded as ever and as keen on work, one may hope that the world may still have the benefit of his ripe experience for many years.

Seaplane Speed Record.

ON Friday of last week, March 30th, a new flying speed record was set up by the Italian pilot, Major de Bernardi, at Venice. Flying a Macchi seaplane fitted with a Fiat engine developing 1000 horse-power, he flew four times over a three-kilometre course at an average speed of 318·4 miles an hour and thereby considerably surpassed the previous record, his own, of 296·9 miles an hour. On one of the laps last Friday his speed, it is said, reached the high level of 348 miles an hour. It was in an effort to surpass Major de Bernardi's earlier record that Flight-Lieut. Kinkead lost his life in the Solent on March 13th. It is understood that an attempt to exceed the new record will be made on a Supermarine Napier S 5 machine and that Flight-Lieut. Webster, who on a similar machine won the Schneider Cup for this country last year, is likely to be the pilot. With the rapid increase in the speeds realised by seaplanes attention is being called to the need for revising the conditions to be fulfilled before a performance can be accepted as establishing a record. The timed distance has to be flown on the level at a regulation altitude and, in addition, a preliminary 500 m. has also to be flown under the same conditions. It is pointed out that with the high speeds now realised the preliminary distance is not sufficiently great to remove the added speed effect over the timed distance of a dive on to the starting point of the preliminary distance. To establish a new record the previous figure must be exceeded by at least 5 m.p.h.

Generation of Electricity in Great Britain.

THE analyses and summaries of the Returns made to the Electricity Commissioners of units generated and fuel consumed at generating stations in Great Britain during the year ending March 31st, 1927, have been prepared in the more comprehensive form adopted in the preceding year. They contain a complete list of all the generating stations from which records were received, and also in most cases a summary of the technical results of operation. The Returns bear evidence of the adverse effects of the prolonged coal strike upon the output and operating results of the various generating stations, and, in view of the difficulties of the situation, it is apparent that the figures given for the average consumption of fuel per unit generated and for the approximate thermal efficiency of operation cannot be regarded as representative of normal practice. Composite stations containing more than one type of prime mover have been classified in accordance with the type of plant by which the major portion of the output was generated. Similarly in arriving at the average consumption of fuel per unit generated in the case of stations at which more than one class of fuel was consumed, the actual fuel consumption at each station has been converted, on the basis of average calorific values, into an equivalent tonnage of the class of fuel from which the largest portion of the output was obtained. Results were received in respect of 570 generating stations, a net decrease of 14 as compared with the preceding year, consequent upon the closing down of 26 stations during the year, and the coming into operation of 12 other stations on or after April 1st, 1926. The total number of units generated at the 570 stations during the year was 8,365,857,198, an increase on the figures for the preceding year of less than 3 per cent. The total coal, coke and fuel oil consumed, however, was 8,856,938 tons, or an increase of 4·8 per cent. The thermal efficiency of the Barton Station of the Manchester Corporation was 21·83 per cent., and 300,771,400 units were generated. The Barking Station generated 183,755,400 units, and its thermal efficiency was 16·33 per cent.

The Late Sir Alexander Richardson.

IT was with great regret that we learnt of the sudden death on Friday, March 30th, of Sir Alexander Richardson, formerly well known as one of the editors of our contemporary, *Engineering*. Sir Alexander was born at Dumbarton in 1864, and at an early age began his journalistic career with an appointment as assistant commercial editor on the staff of the *Glasgow Herald*. During those years he made a special study of shipping and shipbuilding matters and began to contribute occasional articles to *Engineering*. In 1888 the editor of that journal invited him to join his staff. On coming to London he continued to devote much of his attention to marine matters. On the death of Mr. B. A. Raworth in the autumn of 1919 Sir Alexander became joint editor of *Engineering*, and on the death of Dr. W. M. Maw he was appointed editor. From that post he retired in 1924 in order to become consulting editor of the *Shipbuilding and Shipping Record* and of the *Marine Engineer and Motor Builder*. Outside his work for our contemporary Sir Alexander from 1908 onwards took an active interest in the publication of "The Naval Annual," to which in Lord Brassey's time he contributed numerous articles and of which after Lord Brassey's death in 1920 he acquired the copyright in conjunction with Mr. Archibald Hurd. In May, 1918, he was elected to Parliament as Coalition-Unionist member for Gravesend. He was successful in retaining his seat at the elections in December, 1918, and in 1923, but retired from Parliament in the last-named year. In January, 1922, he received the honour of knighthood.

Southern Railway Electrification.

AT the Institute of Transport on Monday, April 2nd, a paper dealing with the electrification of the Southern Railway was read by Mr. E. C. Cox, the company's chief operating superintendent. Mr. Cox, in his opening remarks, said that the President of the Institute, Mr. Roger Smith, had given him the hint that some figures as to the cost of the electrification would be acceptable. The paper proceeded to trace the history of the schemes put forward by the three individual companies which in 1923 became the Southern Railway, and details were given of the various programmes which have since been carried out or remain yet to be completed. During the year 1927 13,135,810 electric train miles were run and the car miles involved gave an average of 5·3 car-miles per train mile. The costs per train mile for the Western, Central and Eastern sections were:—15·33d., 29·34d., and 19·44d. respectively; the cost per car mile was 2·94d., 4·98d., and 3·78d.; the cost of traction per train mile was 6·65d., 12·86d. and 10·08d., and per car mile 1·28d., 2·18d. and 1·96d. It was not possible, Mr. Cox stated, to institute a fair comparison between the sections. The Eastern section, for instance, had only recently been opened, and, therefore, the cost of the maintenance of the vehicles was only a little over 1 per cent. of the whole, as compared with roughly 3 per cent. for the older equipment on the two other sections. On the other hand, the consumption of current per car mile for the Eastern section was 2·30 units, as compared with 2·06 units on the Western section. That difference was caused by the Eastern section having more stations per mile, steeper gradients and more tunnels. On the Eastern section there were approximately 28 miles of gradients steeper than 1 in 125.

An Analysis of Unemployment.

FOR the fourth time the Ministry of Labour has collected and issued statistics of an analytical nature concerning the personal circumstances and industrial history of those making claims to unemployment benefit. The period selected for the examination was the first week of April, 1927. During that period 840,400 people claimed unemployment benefit, or 9·8 per cent. of the estimated number of those insured under the Unemployment Insurance Act, 1920. Of the number claiming benefit, 9748, or a little over 1 per cent., were personally interviewed by the officials of the Employment Exchanges with a view to determining their circumstances and history. An analysis of the information supplied by this 1 per cent. sample presents many interesting results, a few of which only can be mentioned here. In round figures, the employment officers placed 67 per cent. of the claimants interviewed as normally likely to have steady employment, 22 per cent. as likely to obtain a fair amount of employment, 5 per cent. as not likely to obtain a fair amount of employment, 2 per cent. as verging on the unemployable, and 4 per cent. as outside any of these categories. It is shown that during the three and a-half years preceding the selected week about half the men and more than three-quarters of the women had drawn benefit for less than 200 days, or, say, 20 per cent. of the total time. The nucleus of men in receipt of benefit over long periods was 10 per cent. or less. Among women the nucleus, if any, was very small. Interesting information is also given regarding the incidence of unemployment in relation to age. Among men 11 per cent. of the claimants were between 25 and 29 years of age. In the age groups below 25 and above 29 the percentage figure was less than 11 until the age group 50 to 54 years was reached. Of the claimants, 11·3 per cent. fell within that group. The percentage figure then rose steadily with each succeeding group until it reached 17·4 in the 65 to 69 years group. Among women there was a steady fall in the percentage figure with a minimum of 4·1 in the 30 to 34-years group and then a steady rise to 5·9 in the 65 to 69 years group.

New Motor Liners.

THE announcement is made that the Union-Castle Mail Steamship Company, Ltd., has placed an order with Harland and Wolff, Ltd., for a twin-screw 20,000-ton motor passenger liner, generally similar to the "Carnarvon Castle," but embodying such improvements as have been suggested by service experience. The "Carnarvon Castle" was completed in 1926, and has been most successful in operation. She will be followed by a second vessel, which is now under construction at Belfast, and with the ship recently ordered will be the third large motor liner in the Union-Castle mail service. The company has ordered also from Harland and Wolff, Ltd., an 11,000-ton motor vessel for its East African intermediate service, and that ship will be generally similar to the "Landaff Castle," with the exception that she will be propelled by oil engines. The exact type of engine has yet to be decided. It is understood that the Compagnie Générale Transatlantique has placed an order for a quadruple screw, 574ft. motor liner of about 22,000 tons with the Penheot Yard, St. Nazaire. The new vessel will be of the "De Grasse" class, and will be propelled by four 4000 S.H.P. M.A.N. double-acting two-stroke six-cylinder engines, running at 145 r.p.m. Four 700 kW auxiliary generator sets will be installed and driven by a 1050 B.H.P. M.A.N. four-stroke engine of the airless injection type. The engines are six-cylinder units designed to run at 215 r.p.m. The anticipated fuel consumptions have been given as about 0·385 lb. per S.H.P. hour for the main propelling engines and 0·377 lb. per B.H.P. hour for the auxiliary generator sets.

A New Monitor Ship.

THE new monitor ship "Rio Diamante," which was recently launched from the Central Shipyard of William Gray and Co., Ltd., of West Hartlepool, is of interest, not alone on account of her special design of hull, but also because she will be propelled by very efficient quadruple screw steam machinery. She is the thirteenth vessel of the corrugated type to be launched, and the fifth in the cargo fleet of her owners, the Thompson Steam Shipping Company, Ltd., of London. Speaking at the launching ceremony, Mr. M. Huntley said that the four sister ships had since 1921 used 10,000 tons less bunker coal than ordinary type ships, and they had therefore been able to carry a corresponding amount of extra cargo. The saving on the coal and the extra freight earned represented a sum of £25,000. In addition each ship through being corrugated could carry 200 tons extra of deadweight, which meant a further increase in the joint earning capacity of £25,000, making in all a total of £50,000. The new ship has a length of 400ft. with a beam of 53ft. and a depth of 28ft., and is constructed to the designs of the Monitor Shipping Corporation of Newcastle-upon-Tyne. The hull has 17in. framing with a double bottom built on the cellular system, with fore and after peak tanks. Special provision has been made for the carrying of grain cargoes. The propelling machinery will be of the balanced quadruple expansion inverted direct-acting surface-condensing type, and steam will be raised in three 260 lb. coal-fired boilers. The superheaters will be designed to give a total steam temperature of 560 deg. Fah., and a heater will deliver air to the furnaces at a temperature of about 300 deg. Fah. Both the main engines and auxiliaries will be constructed at the Central Marine Engineering Works. Exceptionally economical results are expected.

The Mersey Tunnel.

ON Tuesday morning, April 3rd, the last piece of rock separating the two faces of the lower headings of the road tunnel between Liverpool and Birkenhead was broken through, and civic parties exchanged greetings. The breaking-through ceremony was performed by Sir Archibald Salvidge, Chairman of the Joint Tunnel Committee, and after the Lord Mayor of Liverpool, Miss Margaret Beavan, and the Mayor of Birkenhead, Alderman F. Naylor, had shaken hands through the aperture, the hole was enlarged sufficiently to enable the two parties to exchange greetings.

Report on a Three-Phase Turbo-Alternator.

By Professor S. PARKER SMITH, D.Sc.

No. I.

In June, 1927, the Oerlikon Company completed a 25,000 H.P. steam turbine driven alternator, in the design of which several novel features had been included, while special arrangements were made for measuring the stray losses and fluxes and the heating. With the consent of Mr. T. R. Smith, M.I.E.E., the late Electrical Engineer for the City of Leicester, and Mr. John Mould, A.M.I.E.E., the present Engineer and Manager of the City of Leicester Electricity Department, for which the machine was built, the writer was invited to investigate the alternator while on test. He was glad to accept this commission, for it gave him an opportunity to make a thorough analysis of a modern design and to apply certain test methods which he had been instrumental in developing.

In a turbo-alternator, a designer is faced with two sets of limitations. First, he has the mechanical limitations, which become marked when the peripheral speed of the rotor reaches 145 m. per second (about 28,500ft. per minute), as in this case. The stresses, too, on the stator winding are prodigious in a machine for 23,400 kVA when suddenly short-circuited. Secondly, there are the heating limitations. The amount of air which can be driven through a given type of enclosed machine is strictly limited in practice, and is about 19 cubic metres per second (40,000 cubic feet per minute) in this instance. The output will therefore be governed by the ability of this volume of air to prevent overheating. Thus the designer's skill is exercised, on the one hand, in reducing all losses to a minimum, and, on the other, in securing as uniform a temperature rise as possible.

In addition to the standard no-load, short-circuit, oscillographic and air tests, special experiments were made to determine the temperatures and the losses when the machine gave its rated kVA and voltage at zero power factor, together with the distribution of the stray-load and other losses, stray fluxes and heating of the end plates and end shields. A special connection was used to cause the alternator field to decay rapidly when the excitation was cut off, and the effect of this connection was studied by means of the oscillograph.

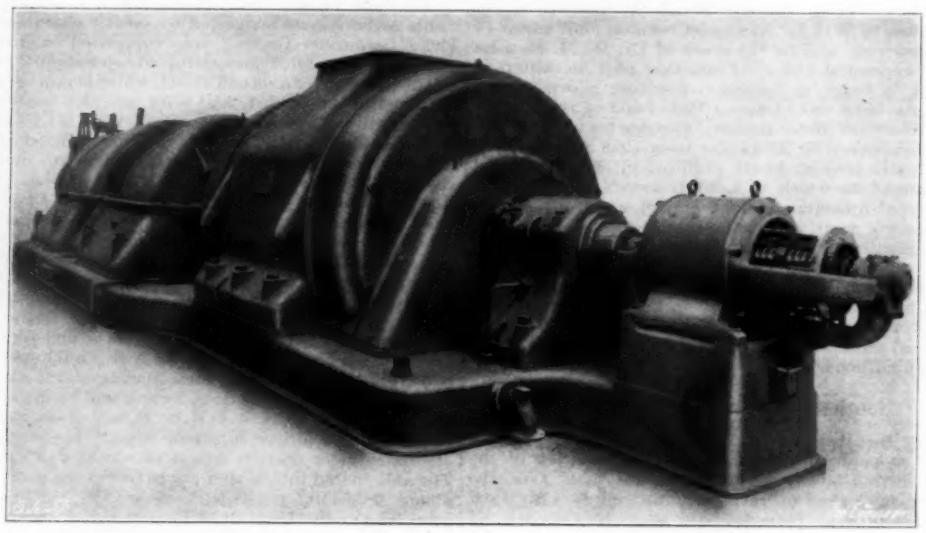


FIG. 1—25,000 H.P. OERLIKON STEAM TURBINE DRIVEN ALTERNATOR. SPEED 3,000 R.P.M.

The normal rating of the turbo-alternator is 23,400 kVA at cos $\varphi = 0{\cdot}8$, 6600 volts, 50 cycles, 3000 r.p.m.

In the following table the leading dimensions of the alternator are given :—

External diameter of stator core	210 cm.
Stator bore	98 "
Rotor diameter	92 "
Air gap	3 "
Overall length of stator core	166 "
Radial ducts in stator	18
Axial ducts behind stator slots	84
Length of rotor core	165 cm.
Radial ducts in rotor	None
Axial ducts in rotor	32

A photograph of the set is reproduced in Fig. 1.

Scheme of Ventilation.

Forced ventilation is obtained by means of fans fixed on the rotor, the air being circulated in a closed system. At each end of the rotor there is a rotor fan and a stator fan.

Rotor Ventilation.—After passing over the inside of the overhang of the rotor winding, the air from the rotor fans passes along thirty-two axial slots cut in the rotor teeth and pole centres—see Fig. 3-B. At definite places in these ducts holes are made in the wedges of the ventilating slots to form exits for the cooling air, whence it passes into the gap and mixes with the air cooling the stator winding. Some of the rotor air also escapes through holes in the rotor end covers.

Stator Ventilation.—Part of the air from the stator fans is allowed to escape from exits between the end plates and the core, after passing through the overhang of the stator winding. The bulk of the stator air, however, after cooling the stator overhang, enters the air gap and slot openings, and the holes behind the slots, whence it passes into the radial channels, where it carries off the heat produced in the stator slot copper and the core—see Figs. 2 and 6.

Measurements of the Cooling Air.—For the purpose of the tests, suitable trunks were fitted to the outlet and the inlet of the machine. The volume of the air was found by measuring its velocity at the outlet. For this purpose, the trunk, which was 105 cm. by 120 cm. in cross section, was divided into thirty equal compartments by means of threads, a honeycomb being provided to obtain more uniform distribution of the air and to prevent eddying. A calibrated anemometer was held over each opening for 5 seconds in succession, whence the average air velocity was obtained. A suitable correction—which was small in amount—was made for the energy in the ejected air.

To obtain the temperature rise of the air, ten thermo-couples in series were stretched across the outlet and a like number across the inlets. The E.M.F.'s induced in these couples were measured by a potentiometer, whence the average temperature rise was found directly.

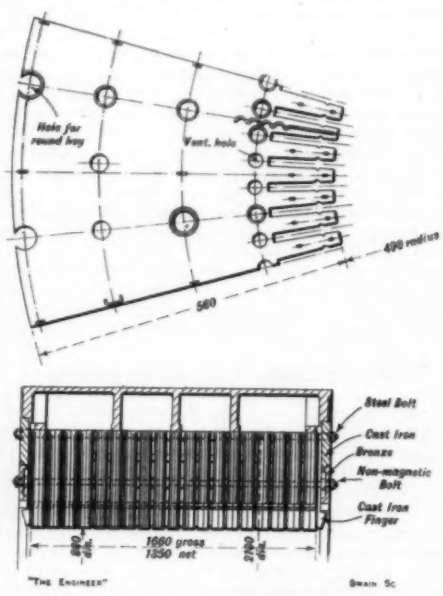


FIG. 2—STATOR CORE AND STAMPING

From the volume and temperature rise of the air and its specific heat and density, the loss carried off by the air was determined for the particular conditions of the test—open circuit, short circuit, load, &c. A correction—small in amount—was made for the heat radiated from the machine. The volume of air measured at the outlet depended, of course, on the losses. It was about 19 cubic metres per second. Similarly, the temperature rise of the air varied from about 10 deg. Cent. for the machine unexcited to about 37 deg. Cent. for the machine fully loaded at zero power factor.

The Stator.

The Design.—The stator was designed not only for low iron and copper losses, but also with a view to reducing the stray load and other losses in the winding, end plates, end shields, and other solid parts, to a minimum.

Core Construction.—The silicon steel employed for the 0·5 mm. laminations had a guaranteed loss of 2 watts per kilogramme at B = 10,000 and $f = 50$, as measured on Epstein's apparatus. Paper insulation was used on the plates, and in the centre of each packet a presspahn liner was inserted. There are eighty-four slots, requiring twelve sectors per circle. Filing the plates was scrupulously avoided, rough edges and burrs being flattened by rolling. The sectors are secured to the stator by round—not dove-tail—keys. Radial ducts chiefly are used in the stator. The distance pieces in these ducts are riveted to three of the ordinary core plates. In the gross stator length of 166 cm. there are eighteen ducts, 1·5 cm. to 2·5 cm. wide, the wider ducts being arranged at the middle. The average thickness of a packet is thus 7·1 cm. The solid end plates for compressing the core are made in two parts, the inner ring being of bronze to reduce losses, and the outer of cast iron. Steel fingers are arranged to press each tooth separately. The inside through bolts are made of non-magnetic material, and are insulated from the core—see Fig. 2.

Winding.—The full-load current is 2050 ampères; consequently a large section of copper is required to carry it. The total cross section of the conductor is 640 square millimetres, or, approximately, 1 square inch. There is one conductor per slot, and to reduce eddy currents induced by the cross flux, due to the current in the conductor, the copper is laminated. This is done in two stages. In the first place, the conductor in the slot is arranged in seven layers, and these layers are cyclically transposed in the overhang, so that in passing through seven slots each layer occupies each of the seven places. It will be noticed that the number of slots per phase enables this to be done. In this way the E.M.F.'s induced in the several layers are equalised, so that no currents can circulate between them. Secondly, each of the seven parts is further laminated into strips. Layers 1 to 5, counting from the bottom of the slot, each consist of three flat strips, 10 mm. wide by 3·2 mm. deep, insulated from one another by 0·3 mm. micanite. These three strips are twisted at the centre of the slot to prevent currents circulating between them. The two upper layers, Nos. 6 and 7, being subjected to the largest differences in E.M.F. induced by the cross flux, are each subdivided into four strips, 10 mm. wide by 2·3 mm. deep. These are also insulated from one another and twisted at the centre to effect an interchange of position in the slot.

In addition to this stray load loss, a loss may be produced on open circuit in the slot copper by the main flux entering the teeth at the sides. To prevent large loss from this cause the winding in this machine does not extend to the top of the slot. The slot is 115 mm. deep and the winding with its mica tube occupies only a depth of 79·4 mm. at the bottom, leaving 35·6 mm. for extra insulation (1·6 mm.), wedge (9 mm.), and air space (25 mm.)—see Fig. 3-A. This long distance between the winding and the rotor surface is also useful, as it gives more space for air in an axial direction and keeps the stator overhang well away from the end covers of the rotor winding. The effect on the losses of arranging the winding in this way will be seen when the losses are discussed.

The overhang of the stator winding calls for especial attention. On the one hand, it must be made so secure that the severest stresses on a sudden short circuit cannot move it in any way, while care must be taken to provide effective ventilation.* An adequate idea of the substantial construction of the overhang of the stator winding can be gained from Fig. 3 and Fig. 4. It will be noticed that the arrangement adopted permits the coil span to be fixed at will. Thus, instead of using full-pitch coils with a span from slot 1 to slot 43, chorded coils are used spanning slot 1 to slot 38. Reducing the span from 42 to 37 slot pitches does not affect the value of the induced E.M.F. appreciably, but it reduces the length of the overhang, which is always unduly long in a two-pole machine.

The Rotor.

An idea of the forged casting required for the rotor of a 23,400 kVA alternator can be gathered from its finished dimensions in Fig. 3-B. The diameter of the rotor body is 92 cm. (3ft.), the length of the rotor body is 165 cm. (5ft. 5in.), while the overall length between the shaft ends is 546·7 cm. (17ft. 10in). The peripheral speed at 3000 revolutions per minute is 145 m. per second (about 28,500ft. per minute).

* Valuable experimental investigations into the effects of sudden short-circuits have been made by the chief engineer of the turbo-alternator department of the Oerlikon Company, H. Rikli—see *Schweiz. Elek. Verein Bulletin*, Vol. 16, page 217, and *Bulletin Oerlikon*, No. 28, 1923; No. 48, 1925.

Looked at in another way, the centrifugal force of a particle at the periphery is equal to 4600 times its weight, or every pound weight at the periphery exerts a force of over 2 tons. It is absolutely essential therefore, to obtain a sound casting thoroughly well forged for this purpose.

The rotor in question was made of chrome-nickel steel with good magnetic properties. Samples cut from the forging were tested for mechanical strength, and a test piece from the rotor was obtained in the form of a trepanned core, leaving a hole 8 cm. in diameter along the rotor axis. This test piece had also to come up to specification, while a careful examination of the inside of the rotor was made by the aid of a special optical arrangement. After the slots for the winding had been cut, careful measurements of the diameter of the rotor were made by means of a special machine capable of measuring to $^1/_{1000}$ mm.† The rotor was then rotated in several stages at speeds up to 3750 revolutions per minute. When run in this way the stresses in the rotor body were the same as when the rotor ventilating ducts were cut and the whole winding was placed in the slots. Following each overspeed test the measurements were repeated. The average permanent expansion at five points was found to be less than $^1/_{1000}$ of 1 per cent. of the length measured.

To reduce the stresses in the rotor and the end covers aluminium instead of copper was used for the rotor winding. The thin end covers, which can be used with an aluminium winding, have decided advantages—see Fig. 3-C. Holes are made in these covers to assist cooling of the overhang. The material used is non-magnetic nickel steel, thereby greatly reducing rotor leakage and eddy current loss from the stray flux of the stator overhang. The slot wedges are also of non-magnetic material to reduce leakage.

In the following table details are given of the rotor and its winding.

Specification of Rotor Material.

	Tensile strength, tons/sq. in.	Elastic limit, tons/sq. in.	Extensibility in per cent.
Rotor, chrome-nickel steel ..	47·5	28·5	18
End covers, non-magnetic nickel steel	50·6	38·0	25

Stresses at 3000 revolutions per minute.

	Stress in tons/sq. in.
Rotor teeth (maximum)	4·3
Surface of bore through rotor	8·7
Rotor end covers	13·3

The rotor slotting is as follows :—

	Dimensions.	Number of conductors.
16 wound slots ..	31·5 × 140 ..	2 × 20, each 5 × 14 mm.
4 ,, ..	31·5 × 125 ..	2 × 17, ,, ,,
4 ,, ..	31·5 × 110 ..	2 × 14, ,, ,,

There are two parallel circuits in the winding, the exciter voltage being 220 volts.

Owing to the high specific resistance of aluminium compared with copper, particular attention had to be paid to the rotor ventilation. For this purpose thirty-two ventilation ducts are cut axially in the pole centres and in the teeth, as shown in Fig. 3-B, the air being ejected near the centre through gaps in the wedges. The cooling of the overhang is also assisted by the holes in the end covers mentioned above.

In order to determine the heating of the rotor winding the temperature rise was measured with various loads at zero power factor. The excitation corresponding to full load at cos $\varphi = 0{\cdot}8$ was determined from the measured characteristics of the machine and was found to be 96·3 kW. With this loss in the rotor the temperature rise was 75 deg. Cent., a value well below that permitted by B.E.S.A. Report No. 225.

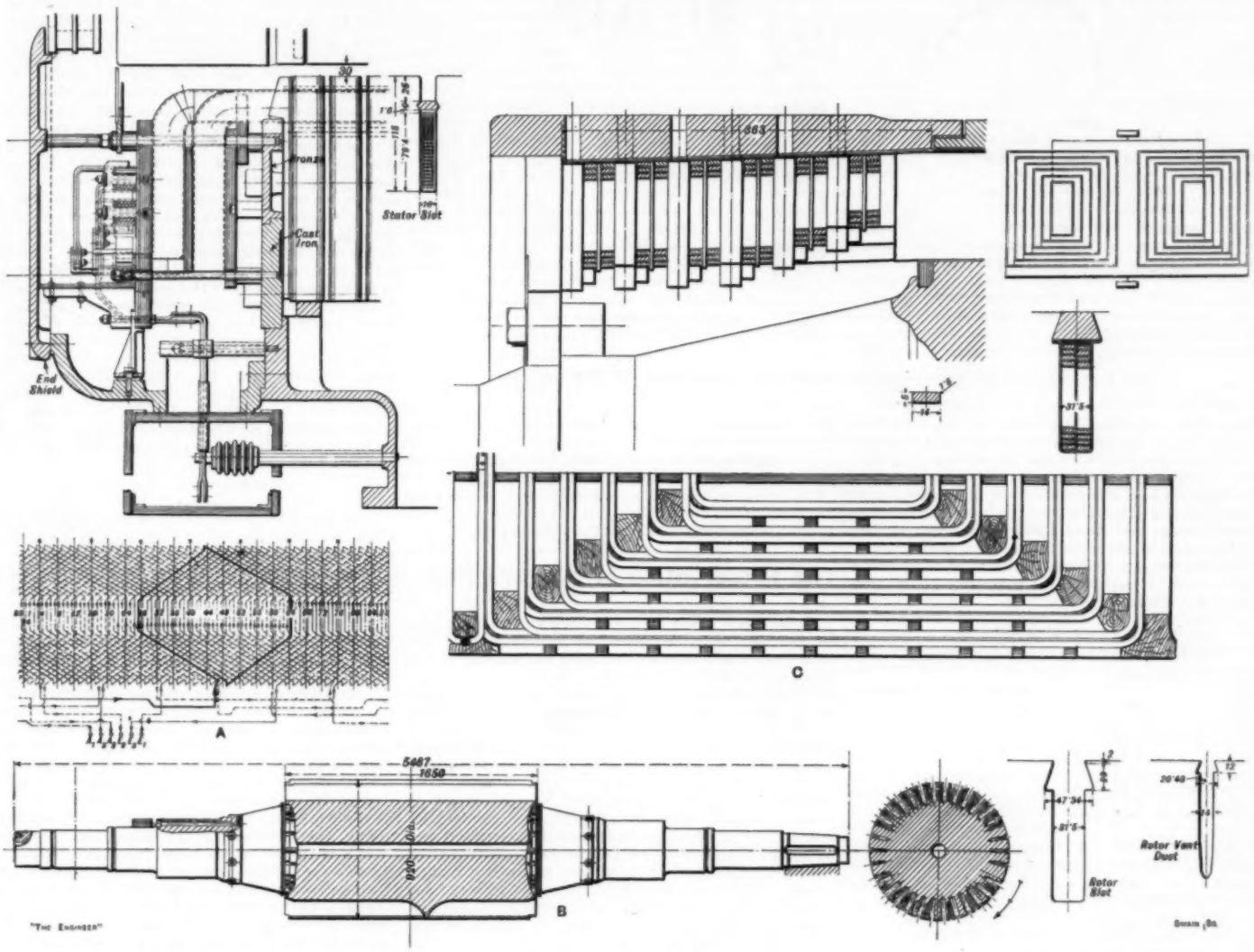
The use of aluminium for the rotor winding therefore not only reduced the mechanical stresses in a marked degree, but with the efficient cooling provided proved to be electrically satisfactory.

Means for Carrying Out Tests.

One of the chief difficulties encountered by the designer of large turbo-alternators is his comparative ignorance of what is going on inside the machine. In addition to fulfilling the guarantees, the designer is concerned to know how the losses and heating are distributed throughout the machine, and also the magnitude and direction of the stresses which occur under abnormal conditions, such as sudden short circuit. In the machine now under discussion, special means were provided for making an exhaustive study of these several points.

Load Tests.—The difficulties in making a load test on a large machine are well known. Even on site, it is not always possible to obtain the desired steady load, while at the works neither boiler power nor load is available and a full-load test might well be prohibitive in cost. The method of obtaining the copper and stray-load losses on short circuit is not satisfactory, owing to the absence of the main flux in the stator under this condition. This difficulty was overcome by using large choking coils to load the machine up to the rated kilovolt-ampères at the rated voltage. This test at zero power factor only requires the losses to be provided, and, owing to the larger exciting current, is somewhat more severe as regards heating than a load test at the specified power factor. The choking coils had air cores, so that the wave shape was not distorted by iron saturation in the load. The coils were also designed for small losses. In this way the losses under load conditions were ascertainable.

Measurement of Separate Losses.—In the section on ventilation, it was explained how the volume and temperature rise of the cooling air were measured. To determine the windage loss these quantities were measured when the machine was run unexcited, while the iron loss at any value of induced E.M.F. was found by running the machine on open circuit with the corresponding excitation. To find the iron loss on load, a knowledge of the value of the corresponding induced E.M.F. is essential. This was obtained by the aid of an oscillogram of the E.M.F. induced in a single conductor in the air gap, which also represents the flux distribution. The



A. Stator End Construction, Winding and Slot. B. Rotor Body and Slotting. C. Rotor End Construction, Winding and Slot.

FIG. 3

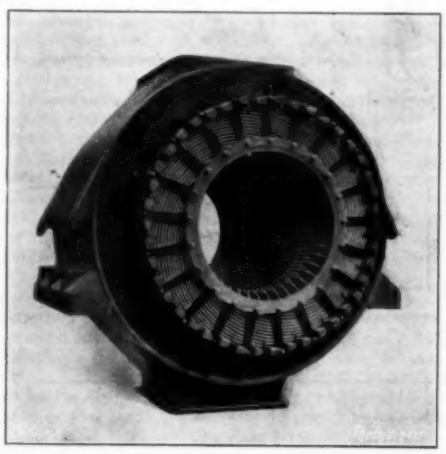


FIG. 4—BRACING OF OVERHANG OF STATOR WINDING

† See *Bulletin Oerlikon*, Nos. 73 and 74, 1927.

stator copper loss includes losses due to the stray field, and there are also extra losses in the solid iron parts of the machine which do not occur on open circuit. The sum of these stray load losses was found by measuring the total loss when the machine was run fully loaded at zero power factor and deducting the corresponding windage, excitation and iron losses.

The bearing loss was found from the volume and temperature rise of the oil.

Local Heating and Local Losses.—In order to discover the heating and losses throughout the machine, fifty thermo-couples were embedded in various parts of the stator in the positions indicated below and shown in Figs. 5 and 6:—

Embedded Temperature Detectors.

Position in machine.	Temperature and loss measured.
Middle of centre packet of core plates	Along centre of core radially
Middle of end packet of core plates	Along end of core radially
Between conductors at middle of machine	Along stator slot radially
Between conductors, 79 cm. from middle of machine	4 cm. inside slot
Between conductors, 95 cm. from middle of machine	12 cm. outside slot
Middle of overhang—outside plane	Stator overhang copper
Outside of overhang—outside plane	Stator overhang copper
Middle of overhang—inside plane	Stator overhang copper
Inside bronze end plate	End plates
,, cast iron end plate	End plates
,, vent ducts near gap	Cooling air axially
,, vent ducts near frame	Cooling air axially
,, end shield	In shields
,, intermediate shield	In shields

For measuring the E.M.F.'s induced in these elements —or, in other words, the temperature difference between the junctions—a potentiometer was used. The method is fully described in an article by the test engineer, A. Schnetzler, "Thermoelemente und deren Anwendung zur Messung von Temperatur-differenzen," *Schw. Elek. Verein Bulletin*, Vol. 16, page 595.

To find the temperatures, measurements were taken after steady conditions had been reached.

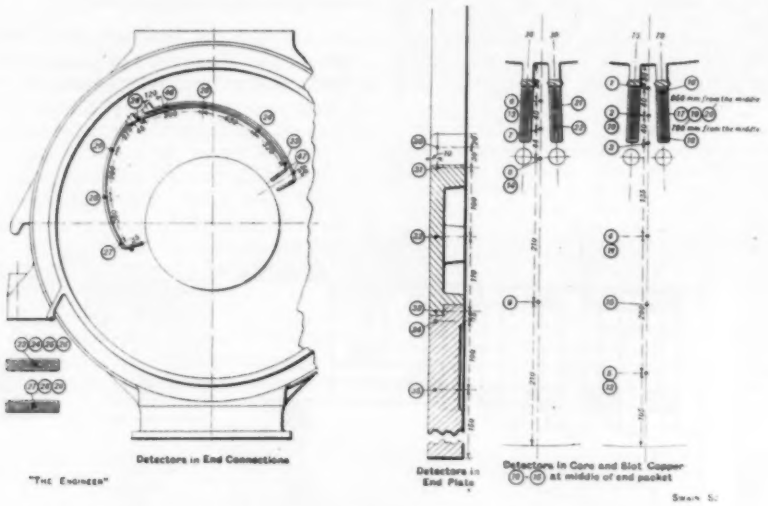

Detectors in End Connections
Detectors in End Plate
Detectors in Core and Slot Copper
at middle of end packet
"The Engineer"

Fig. 5—Positions of Temperature Detectors Embedded in Stator

For determining the losses, the initial rate of temperature rise was measured.

The application of the methods referred to will be explained in the following sections of the report.

(To be continued.)

The Preservation of Niagara Falls.

Much concern has been felt during recent years at the rate at which the Horseshoe Fall at Niagara has been eroded and at the continued unwatering of the flanks of the Fall on both sides. Following an extensive correspondence and exchange of views between the Governments of the United States and of Canada during the latter part of 1925 and the early part of 1926, arrangements were made for an extended investigation into the preservation of the scenic beauty of the Falls and of all the factors relative thereto. The membership of the International Niagara Board of Control, which, since July, 1923, has, under the instructions of the two Governments, supervised and controlled the abstraction of the water permitted to be diverted under Article V. of the Boundary Waters Treaty of 1909–10, was enlarged from two to four and constituted into a Special International Niagara Board for the purpose of carrying out this investigation. The members of the Board are:—Mr. J. T. Johnston, Director of the Dominion Water Power and Reclamation Service of the Department of the Interior; and Dr. Chas. Camsell, Deputy Minister of Mines, representing Canada; and Major De Witt C. Jones, of the Corps of Engineers, U.S. Army, District Engineer at Buffalo, N.Y.; and Mr. J. Horace McFarland, Past-President of the American Civic Association, and Chairman of the Fine Arts Commission of the State of Pennsylvania, of Harrisburg, Pa., representing the United States. Joint terms of reference were agreed upon by the two Governments in October, 1926, and referred to the Board for action.

Since its appointment the Board has been engaged in a comprehensive review of all the factors and features which actively enter into or are in any way connected with the scenic beauty of the Falls and rapids. It has been making a study of the geological features of the Falls and vicinity, as well as of the rate of recession of the Falls in the past, and to be anticipated in the future. Furthermore, it has been preparing an analysis of the water supply factors of the Niagara River to determine:—(*a*) The flow actually available in the river from 1860 to date; (*b*) the records of the withdrawals from the Great Lakes System and from the River itself, which have affected the flow over the Falls and through the rapids; and (*c*) the theoretical flow which would have been available if there had been no withdrawals. It has also been preparing an analysis of the hydraulic conditions in the River, and particularly at the Falls and in the rapids above and below, and has studied the ice conditions which have obtained in the past and which may be anticipated in the future. Finally, it has made a carefully reviewed remedial works designed to restore and preserve the scenic values of the Falls.

Very considerable progress has been made in all these directions, but the investigations are not yet completed. However, as the Board feels that the initial works which it has to propose should be undertaken without delay, it has issued an interim report. A second and final report is promised for a later date.

We have been favoured with an advance copy of the interim report, and we propose in what follows to give a summary of its principal contents.

Conditions at the Falls.

It is pointed out that the general appearance of the Falls has been the subject of serious consideration by the two Governments since 1905.

Investigations have shown that surveys made in the years 1764, 1842, 1875, 1906, 1917, 1925, and 1927 indicate a continuous recession of the central portion of the crest line of the Canadian or Horseshoe Falls. The effect of this recession has been to lengthen the crest and to leave the flanks of the Horseshoe on either shore more or less denuded of water, the degree depending upon the total volume of flow over the Falls. Moreover, the low cycle of levels in the Great Lakes System for several years past, which culminated in the extreme low water of 1925–26, has been reflected in the flows of the Niagara River, which reached the minimum on record in February, 1926. These low flows have augmented the baring of the flanks of the Horseshoe Fall and reduced the supply available for the American Falls.

The withdrawal of water from the Great Lakes System for (*a*) the Chicago Sanitary District, (*b*) the Welland Canal, and (*c*) the New York State Barge Canal, and the withdrawal of water from above the Falls, on both sides of the river, for power purposes, have combined to reduce the flow in both the American and Canadian channels and have increased the unwatering of the flanks of the Horseshoe. As a set-off against this diminution, however, the reduction in the total flow has, in some measure, retarded the rate of erosion of the crest of the Fall.

Attached to the report is a copy of a vertical aeroplane photograph of the Falls, on which have been plotted the positions of the crest line of the Horseshoe

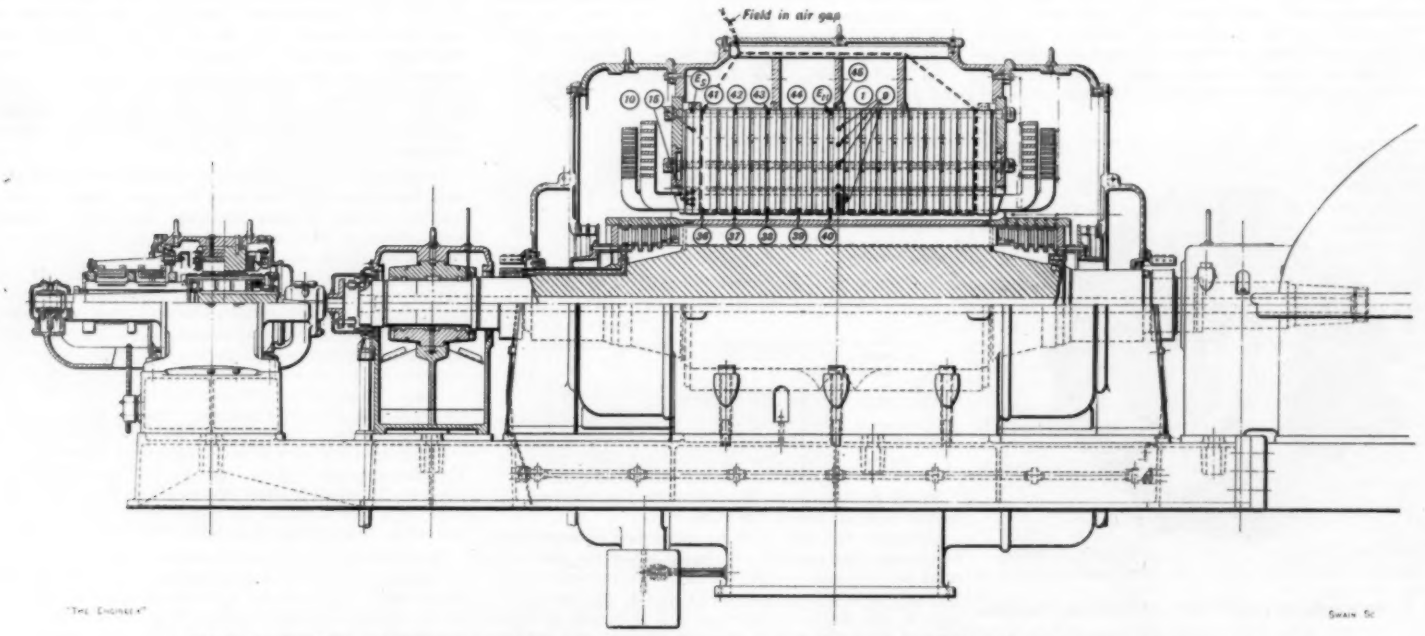


Fig. 6—Positions of Temperature Detectors Embedded in Stator of 25,000 H.P. Oerlikon Alternator

at various dates in the past as determined by the best available surveys. Lines have been added to indicate the probable positions of future crest lines if the Fall is left to itself, these lines having been tentatively estimated by the Board in its geological study of the Falls. The salient features of this photograph are reproduced in the sketch given in Fig. 1 below.

The report goes on to explain that there are two deep and swift channels in the rapids, just above the Horseshoe Fall, which are separated by an area of very shallow water. It is evident, it is stated, that the two strong currents in these channels have, since about the year 1800, and possibly for many years before, converged and met near the central part of the river, thus causing especially rapid erosion in the central part of the Fall. Erosion at the flanks,

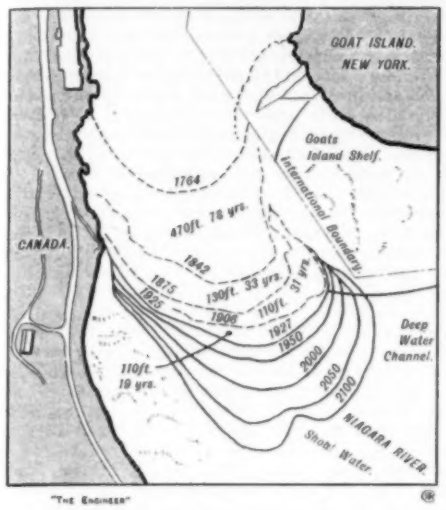


FIG. 1—HORSESHOE FALL SHOWING RECESSION

particularly at the Goat Island shelf at the United States end of the Fall, has practically ceased, owing to the draining of water from the shelf by the upstream movement of the Horseshoe and to the diversion of water for power purposes. The further condition exists that, when the main Fall was passing the Goat Island shelf, the water at the flank was not sufficient to cut through the hard stratum of rock, which lies near the surface of the "Maid-of-the-Mist" Pool below the Fall, which has allowed a talus of large rocks that fell from the cliff to rest upon the stratum at the base, thus effectually preventing undercutting at that part of the Fall.

The rate at which the central part of the Horseshoe moves upstream has been several times calculated in recent years, the determined rate in each case depending upon the definition given to the movements and the method used in the calculation. The latest determination made by the Board, with the aid of competent geologists, and considering only the actively cutting central part of the Fall, shows a mean rate of recession of the crest of 3·7ft. per year since 1842, and of 2·3ft. year since 1906. The direction of maximum recession is now, and for more than twenty years has been, up the deep channel on the Canadian side and not in the so-called "notch," where, of recent years, the recession has been almost negligible. The Horseshoe is now, it is asserted, cutting back at a decreasing rate, and the rate will continue to decrease.

The reasons for this statement as set out are as follows:—

First, whereas, formerly, the two deep swift currents in approaching the crest converged to a single point and caused violent undercutting at and near the point of convergence, these two currents, being now separated nearer the crest of the Fall by the central shoal, do not so completely combine their cutting power, but each tends more and more to work on its own side of the Horseshoe. For some years, therefore, the erosion caused by these main currents has tended to follow the diverging channels upstream, with the result that the toe of the Horseshoe is growing broader rather than being cut into a single notch. The toe of the Horseshoe is broader now than it was eighty-five years ago, and it will continue to broaden, as it moves upstream, for many hundreds of years to come.

Secondly, the fall recedes by undercutting, and not by wearing away at the lip. If this were not true, says the report, the fall would, long ago, have become a cascade or series of rapids. The floor of the upper rapids and the crest of the Fall is a very hard and thick stratum of limestone. Recession occurs through the falling of large blocks of this limestone as it is undercut through the wearing away of softer underlying strata. The thickness of this upper stratum increases from about 78ft. at the present crest line to about 130ft. at the head of the upper rapids. As the crest moves upstream the increased thickness of this stratum will decrease the rate of recession.

Thirdly, as the Falls recede, the active part of the crest line will increase in length, and, even assuming no further diversion, the flow per unit of crest will decrease. It is estimated, in fact, that by the year 2100 the length of the active part of the crest line will be about 75 per cent. greater than it is at present. At that time the average flow per unit of crest will be between one-half and two-thirds of the present flow. This natural thinning out of the flow will decrease the rate of recession.

Fourthly, during recent years a large part of the flow has been diverted for power purposes, and that fact has probably decreased the rate of recession.

Thus, it is apparent, continues the report, that the Horseshoe Fall will not, if left to itself, become a mere cascade and destroy itself by cutting a deep "notch." On the contrary, there is every reason to believe that the active part of the Horseshoe will broaden out, that the crest line will lengthen in graceful curves, and that, if adequately supplied with water, the main part of the Horseshoe one hundred or two hundred years hence will have an appearance equal or superior to the present aspect. It is estimated, in fact, that the recession will not progress to the point of draining the American Fall for at least 2000 years.

The Report goes on to explain, however, that these remarks apply to the main part of the Horseshoe alone, and not to the present flanks. The Goat Island shelf, and a section of the flank near the Canadian shore are already practically bare. Within recent years a 415ft. section of the crest at the Canadian flank has been filled up and coverted from crest into a part of the wall of the gorge. Within the reasonably near future the Goat Island shelf will be completely dry, even at high water seasons, and that part of the fall, if left to nature, will take its natural place as part of the wall of the gorge.

However, the comparatively simple and inexpensive engineering works which are outlined below, will, it is asserted, enable that part of the Fall to be re-watered, thus forming the connection necessary to bind the American Falls with the enlarged Horseshoe into an harmonious whole. The same condition exists at the Canadian flank, but in less degree and with less necessity for remedial works.

The proposals of the Board are illustrated in the Report, by means of an aerial photograph, on which the positions of the suggested works are indicated. In Fig. 2 we give a sketch which embodies the main features of this photograph.

The recession of the American Falls is negligible. In the time since these Falls became separated from the

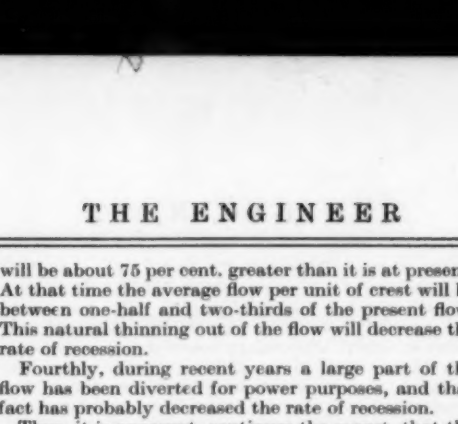


FIG. 2—PLAN SHOWING PROPOSED REMEDIAL WORKS

Horseshoe, the crest line has not receded much, if any, more than the dry crest of the adjacent walls of the gorge. This condition is due to the fact that the flow over the flank of the main fall as it receded along and past the face of the present American Falls was not sufficient to cut through the hard stratum at the foot, thus leaving a resting place for the huge masses of rock which fell from the cliff and which form the talus at the foot of the falls. There has never been a sufficient flow over the American Falls to cause any material wearing away of this talus, which, so long as it exists, prevents undercutting and consequent erosion. No increase of flow, which may be considered within reason, will change the situation.

LOW LAKE STAGES.

With regard to the abnormally low water conditions which culminated in February, 1926, it is the opinion of the Board, after reviewing reports and records of the United States Weather Bureau of the Meteorological Service of Canada, that the cycle of low precipitation will, in the natural course of events, be followed by years of higher precipitation with accompanying higher lake levels and higher flows in the Niagara River. There is no evidence, it is stated, that there has been any consistent long period change in the average rate of either precipitation or evaporation over the Great Lakes watershed. Recurrent and dependable periods of average high flow in the Niagara River may, therefore, be anticipated with only rare periods of abnormally low flow.

REMEDIAL WORKS.

The Report then goes on to say that all the plans for remedial works hitherto suggested have contemplated replenishing the flow over the flanks of the Horseshoe Fall and in the American channel at the head of Goat Island. Certain plans, including those for the construction of a curved weir across the main part of the rapids above the Horseshoe, and those for distributing the flow by numerous islands in the rapids, have had for their main object a radical reduction in the heavy flow over the central part of the Horseshoe. The premises upon which the assumed necessity for such reduction has been based are:—

A. That the American Falls are more beautiful than the Horseshoe, and that, consequently, the general effect would be enhanced by thinning out the latter so as to make it similar to the former;

B. That the Horseshoe is in danger of committing suicide, and that the proposed thinning out would materially check the erosion; and

C. That such works would make available additional water for power purposes.

The final report of the Board will, we are told, deal fully with these premises and plans. The present Report states, however, that, in the fully considered opinion of the Board, the first and second premises are not sound. To thin out the Horseshoe to such an extent as entirely to substitute white water for the present beautiful green depths, which constitute one of the principal attractions of the Horseshoe, would destroy the contrast between the two Falls, which is one of the chief features of interest. The major construction works in the main part of the rapids, necessary to accomplish such a result, would destroy the broad expanse of cascades, which constitutes another of the chief charms of Niagara.

"The Falls," the Report asserts, "are in no danger of 'committing suicide,' and even if such were the case, the thinning out of the central flow of water would only retard erosion and not stop it."

For the reasons set out above the Board has rejected plans involving elaborate works in the main part of the rapids as unnecessary to accomplish the desired results, and as destructive of some of the principal natural scenic effects. On the contrary, the type of construction which it considers to be best suited properly to re-water the flanks of the Horseshoe is a combination of excavations and submerged weirs carried from the shores near the flanks into the adjacent main currents only far enough to accomplish the desired deflection of water to the flanks. This plan, it is urged, is susceptible of progressive extension upstream and into the rapids to the extent required to mask the effect of any reasonable additional diversions which may be agreed upon.

The various types of remedial works which have been considered have been tested on the model of the Falls built by the Niagara Falls Power Company.* The Board remarks, however, that, while model demonstrations serve a most useful purpose in indicating the general results which may be anticipated from different types of remedial works, it is not felt that the specific performance of works of that character and magnitude in the turbulent waters of the upper rapids can be successfully predicated upon experiments on even the most accurately constructed small-scale models. It adds, however, that the model demonstrations have effectively shown that remedial measures which will greatly improve the scenic value of the Falls are eminently practicable.

INITIAL WORKS RECOMMENDED.

The most serious injury to the spectacle as a whole is the progressive laying bare of the Goat Island shelf and the Canadian flank. The other principal injuries consist in the thinning out of the American Falls and of the rapids above both Falls, and of the reduced flow between the Three Sister Islands and Goat Island. The laying bare of the Goat Island shelf is the most serious, because the shelf is a prominent feature which should, and did formerly, carry enough water to bind the Falls into a single harmonious picture, but which with the present meagre flow gives the immediate impression of inadequate water supply.

This part of the Falls, says the Report, can be given an ample sheet of water through the construction of relatively simple and inexpensive works, which would take the form of submerged weirs with incidental and co-ordinated excavation designed (*a*) to deflect water from the heavy current to the north of the central shoal, and (*b*) to distribute the water over the floor of the shelf and to the crest of the Falls, and to be merged into the general effect of the existing cascades. A flow not exceeding 4000 cubic feet per second, at low stages, would, it is believed, be sufficient to produce the results desired.

The conditions on the Canadian flank of the Horseshoe, while not quite so serious as those on the Goat Island shelf, are of the same general character and are susceptible of the same type of treatment. It is proposed that the works in this area shall consist of the removal of exposed boulders and shoals in conjunction with the construction of submerged deflecting weirs lying diagonally and irregularly across the current and intercepting a portion of the heavy flow in the channel to the south of the central shoal, together with such co-ordinated excavation as may be necessary. It is stated that the effect of these works would be to distribute to the Canadian flank sufficient water to restore its crest line and to re-water the rapids

* [This model was illustrated and described in our issue of October 28th, 1927.—ED. THE E.]

immediately above. The water which it would be necessary to draw from the deeper channel to ensure that effect during periods of low water should, it is estimated, not exceed 2000 cubic feet per second.

What proportion these volumes bear to the total flow in the River may be gauged from the fact that when Lake Erie is at an elevation of 571·8ft., or 1ft. above low-water datum, the total flow in the river is about 191,000 cubic feet per second.

The American Falls.

With 191,000 cubic feet of total flow the flow over the American Falls is about 7100 cubic feet per second. That flow increases or decreases about 240 cubic feet per second for a rise or fall of 0·1ft. in elevation of the quiet waters above the first cascade, known as the Grass Island Pool. With a flow of 7000 cubic feet per second, though the fall retains much of its scenic beauty, there is nevertheless left, says the Report, an impression of thinness, especially under certain conditions and intensities of light. A flow of 9000 cubic feet per second produces a very material betterment, while a further improvement is noticeable when the flow rises to 12,000 cubic feet per second.

The lack of volume in the American Falls and rapids, and of flow around the Three Sister Islands, can, the Report maintains, be remedied by raising the level of Grass Island Pool by approximately 1ft. at low stages so as to throw more water against the head of Goat Island. It is suggested that the construction of a submerged weir in the general position shown in Fig. 2 is the logical method of raising the level of the water in the Pool to the desired elevation. It is maintained in the Report that such a structure as is proposed, extending irregularly across the current, with, possibly, auxiliary structures if required, would be quite inconspicuous, and would probably result in nothing more than a slight ripple or rapid. It could be of rubble mound construction, submerged so deeply as to afford no obstruction to the flow of ice.

Results Anticipated.

The results which are, according to the Board, to be anticipated from the construction of the suggested works on the two flanks of the Horseshoe Fall will be (*a*) the insurance at all seasons of an unbroken crest line from shore to shore; (*b*) the maintenance of the present blended green and white colour effects of the Fall; and (*c*) in some proportionate measure a modification of the rate of erosion in the bend. The works in Grass Island Pool will ensure an adequate flow in the American rapids and Falls and between the Twin Sister Islands.

Estimated Cost.

The estimated costs of the suggested works, with allowances for changes and contingencies, are as follows:—

	Dollars.
Works on the U.S. flank of Horseshoe	450,000
Works on the Canadian flank of Horseshoe ..	300,000
Works in the Chippawa-Grass Island Pool ..	1,000,000
Total	1,750,000

or, say, £350,000. It is suggested that the first step to be taken in connection with these initial operations should be the construction of the works at the Canadian and American flanks of the Horseshoe Fall, and that the second step should be the placing of the upper weir.

Institution of Naval Architects.

No. II.*

THE QUESTION OF FUEL FOR SHIPS.

We continue below our account of the discussion of Sir John H. Biles' paper on "The Question of Fuel for Ships," which was read on the first day of the annual general meeting of the Institution of Naval Architects on the 28th ult. The paper itself was printed in an abridged form in our last issue.

Mr. S. G. Visker did not agree fully with Sir John Biles that the cost of producing power was the decisive factor when considering whether to adopt a steam plant or a motor, neither did he agree that it was a comparatively easy matter for steam plant to compete with the motor. Of course, the cost of producing power was of very great importance, but it was not decisive. If it were, there would not be a single steam engine being built to-day, for, despite the calculations made in the paper, practice had shown already that the motor had not been beaten by any steam installation in a ship so far as cost per horse-power was concerned. It was useless to put forward other calculations against those put forward by Sir John, because the value of the figures depended largely upon the type of motor, the sort of service to which it was put, the price of oil, and many other circumstances. He referred, however, to the results obtained with one of the vessels of his company—the Nederland Stoomvaart Maatschappij—the "Bintang," which was converted some four years ago from an ordinary triple engine steam into a motor ship, two of the four boilers being left in the ship for working the deck machinery in port. They were able also to fit in the existing engine and boiler-room a single-acting two-stroke Sulzer motor of 3600 S.H.P. instead of the original triple engine of a little over 3000 I.H.P., effecting an increase of speed of about 1½ knots. The conversion had resulted in a net saving of between £4000 and £5000 annually, allowing 10 per cent. per annum for depreciation and all expenses of repairs, &c. The repairs had cost considerably less than those of a steam engine, as was the case with any good motor, if well looked after and properly handled. If the motor were not carefully looked after, however, big repairs, involving considerable expenditure of money and time would be necessary, and for that reason he advised the tramp owner to stick to his triple steam engine if he were sending his ships round the world in the hands of men who were not the best of engineers. In his opinion, the motor was not suitable for a tramp; neither was it suitable where very big powers were used, as in the case of the large Transatlantic liners, however cheaply the power might be produced—at least, not at the present stage. As to the possibility of building steam plants for ships, capable of competing with the motor, he warned shipowners not to be too optimistic, and urged engineers carefully to study the problem and to improve engines, turbines and boilers, because certainly to-day they were not in a position to make the steam engine compete successfully with the motor from the point of view of cost of fuel. However, he was a strong believer in the steam engine, especially for the future, when oil supplies were bound to run short and when oil would become expensive, and it was the duty of the engineer to improve the steam engine. With regard to the "King George V.," he was very much afraid that she would encounter difficulties when on long voyages and when she was not able to return home every few days, as she could do at present. At any rate, a high-pressure installation was certainly not suitable for most ships and ships' engineers in the present state of development, and it would be necessary to carry out a good deal of work before high-pressure plant would be as reliable as ordinary plant to-day.

As regarded pulverised fuel, there was less reason for optimism. The difficulties connected with its use were considerable, but they were accepted because of the very high efficiency of the process. It was possible to burn pulverised coal with practically the theoretical amount of oxygen, which meant no surplus of air, and, in consequence, a very high flame temperature. That, however, required an exceedingly large combustion chamber of brickwork before the real boiler, if one were to avoid burning the boiler tubes and plates, and that was not practicable in ships. Again, the process enabled one to burn very cheap fuel. Cheap fuel, however, could not possibly bear the cost of transport to the coaling stations abroad, where the ships would have to bunker. Thus the two principal advantages in the use of pulverised coal were lost, and it was doubtful whether the small advantage that remained would counterbalance the cost of the installation and its rather expensive upkeep. As to mechanical stokers they were, he said, a success. It was difficult to say how great a saving was effected by their use, but the experience of his company was that the saving did not exceed 5 per cent. In larger plants, however, the saving might be greater, because it would be possible to reduce the number of firemen employed.

Engineer-Commander Hawkes emphasised the importance of running costs, and said it was unfortunate that, as soon as an attempt was made to increase efficiency, owners were faced with higher first costs of plant, and usually with higher upkeep costs. There had been difficulties in the employment of higher temperatures in land stations, and he understood, on good authority, that in some of the big boiler plants fed with mechanical stokers the cost of boiler maintenance alone was 2s. 6d. per ton of coal fired, and in extreme cases 4s. If pulverised fuel-fired water-tube boilers were to be used, we must be able to utilise any coal that was likely to be bunkered. Ash content was an important matter, and he believed that most of the plants working in America used coals which were far superior to most British coals.

Mr. J. H. Narbeth said that, in the paper, machinery of 3600 S.H.P. was taken as a standard of comparison, but that small size scarcely did justice to the new system. The advantages would be much more real for installations of over 5000 S.H.P. With higher power also the desirability of retaining smooth-running turbines, instead of adopting Diesel engines, with their great reciprocating masses, would be far more pronounced. The change of attitude of shipowners regarding water-tube boilers was also very gratifying, in view of the hostile criticisms of the suggestion to make a greater use of water-tube boilers in the mercantile marine, which was put forward in 1923 in a paper on "A Proposed Aircraft-carrying Mail Steamer," submitted jointly by Sir Eustace D'Eyncourt and himself to the Institution. Sir John Biles, in Table I. of the present paper, had proved that the Diesel—or heavy oil engine—was the most expensive type of propelling machinery to be found to-day. How, then, could the very widespread adoption of the Diesel engine for ships of all sizes be explained? Steam engines were even being taken out of a considerable number of ships in order that Diesel engines might be installed, a sure indication that there was something the matter with Sir John's broad conclusions. The first table in Sir John's paper showed that during the last three years the tonnage of ships built to be propelled by oil engines was about three times as great as the aggregate of all turbine-driven tonnage, including both coal-fired and oil-fired vessels. The experience of the members of the Diesel Engine Users Association, which related to land engines chiefly, indicated quite clearly that heavy oil engines would maintain their test bed efficiency for very many years, and that the charges for maintenance were, as a rule, extremely small. The results obtained afloat with good engines pointed in the same direction. For instance, two 14-knot motor ships which had been running for just three years had cost only about £500 per annum per ship, for about 4500 S.H.P. in each ship, and the lubricating oil used for all purposes on those two ships amounted to less than half a gallon per 100 S.H.P. per day. These figures were in a tremendous contrast to those given by Sir John Biles, and were much more nearly representative of good Diesel engine practice. He ventured to suggest a variation in the bases of the calculations underlying Table I. In the first place, the standard rate of 18½ per cent. for interest, depreciation and insurance could not apply equally to such highly diversified types of machinery. The simple low-pressure steam engine and the slow-running heavy-oil engine would last much longer and must cost much less for maintenance and insurance than the high-pressure and in some cases highly complicated steam installations, and he suggested a substantial variation in these percentages. Secondly, while an oil engine would do its work on service with a fuel consumption very near to that recorded on trial, it was notorious that the quantity of coal used in steamships might be far greater than on the trial trip. A figure of 25s. per ton would be more reasonable than 20s., but in any case he suggested 22s. 6d. as a basis, and 70s. per ton instead of 80s. per ton for oil. There was a growing surplus of oil in the world, and there were many indications that the future would reveal larger sources than had yet been tapped. When all these corrections were made, the oil engine would show up much more favourably than it did in the paper. Every effort to make more efficient use of coal, he said, had his very hearty support, but he was more than ever convinced of the folly of trying to burn all kinds of coal in a furnace, and, consequently, of the great desirability of pressing forward every kind of investigation which would help towards the better use of coal.

Sir John Biles' oral reply to the discussion was very brief, and presumably he will reply further in writing later. His answer to Mr. Narbeth was to the effect that in calculations such as those made in the paper it was necessary to make assumptions, and that different assumptions would lead to different results, but it was left to the judgment of those who studied the paper as to which assumptions were nearest the truth. The question of a uniform charge for interest, depreciation and insurance was a debatable one, but he knew of no higher authority than the shipowners, who had given the information on which the calculations were based. Dealing with references which had been made to the necessity of carrying fresh water to make up feed, and that that ought to have been allowed for, he said the amount actually used, he believed, was only about 0·3 or 0·4 per cent. of the total amount of water that went through the engine. It was not his intention, he said, to suggest that it was easy to carry out high-pressure installations; his purpose was to raise the matter for discussion.

A vote of thanks having been accorded Sir John, the meeting was adjourned.

Sir Eustace Tennyson D'Eyncourt and Sir John Biles presided in turn during the early part of the afternoon session on Wednesday, March 28th, in the absence of the President. The first paper taken was written by Mr. Foster King, and was entitled "The Bending and Loading of Ships." An abstract of this paper will be found on page 372.

The Bending and Loading of Ships.

The discussion was opened by Dr. J. Montgomerie, who complained that the paper was difficult to follow. Towards the end of the paper, for example, an important conclusion was reached, but he did not see on what grounds; nor did he see the reason for the correction which the author had set forth. The formula put forward was said to give results which were in accordance with observed facts, but, of course, a great deal depended on the facts observed and the methods employed in observing them. In that connection he referred to a pronouncement by Mr. Foster King in 1915 to which he (Dr. Montgomerie) had always attached importance. The function of length mentioned in the paper, said Dr. Montgomerie, was 0·0165, and the corresponding function in length as given in 1915 was 0·023 L. This difference might be explained by the correction which followed in the present paper, but, in view of his inability to apply it, he asked Mr. Foster King if the results of the present investigation agreed in general with the 1915 statement. The general subject of the paper was concerned with the ancient controversy as to the relative states of stress in fine and full ships, and, with all deference to the eminent men who had undertaken an investigation of the problem, he was of opinion that it contained so many indeterminate factors and was also of such complex character in itself, as to defy refined mathematical methods of solution. So far as results of absolute value were concerned, the only effective

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method of obtaining such information was an experimental one, carried on over fairly long periods of time, and embracing as many individual cases as possible. An official of Lloyd's Register of Shipping was now at sea making actual and scientific observations of strain in a cargo vessel, and it was greatly to be desired that that method of attack should become widely employed. On the general question, and apart altogether from mathematical investigation, his opinion was that practical experience, for what it was worth, supported the view that there was no sensible difference in regard to general stress conditions as between a full ship and a fine one.

Sir Westcott Abell said it appeared to him that Mr. Foster King had endeavoured to suggest that, instead of making a laborious calculation on a vessel poised on waves, the process could be simplified by using the investigation he had made by averaging up a number of conditions. The making of such a calculation, of course, was not an easy matter, and, therefore, was generally avoided. He was puzzled with regard to the correction to the formula given in the paper; he could understand that Mr. Foster King wanted to correct for the variations as between actual draught and designed draught, but could not follow why the correction did not always apply. The analysis, presumably, was meant to be made for ships that were fully loaded, and when departing from the fully loaded condition a correction should be made.

Mr. Maurice Denny, speaking on the suggestion that by the aid of the formula put forward in the paper, shipbuilders would be able to give the owners guidance in connection with the loading of the vessels, said he agreed with Mr. Foster King that the facility of application of the method was relative. A good many years ago the only method of dealing with the number and position of bulkheads was to carry out a long, laborious and complicated calculation. Since that time the Bulkhead Committee had advanced a method which was relatively simple, but the application of which still absorbed a good deal of time. He wondered whether, even with the relatively simple method of Mr. Foster King, many shipbuilders would feel inclined to carry out the detailed calculations which would be necessary in order to give the shipowner the comparative strength of the ship in different conditions of loading.

A somewhat detailed criticism of the paper came from Mr. E. J. Champness, who said that it was possible to read into the wording of the paper the suggestion that the classic wave form calculations were an entirely futile procedure. No one would suggest, he continued, that the usual calculations were absolute, but he did submit that such calculations were based on principles of mechanics which had stood the test of time and practice in all branches of engineering, and, intelligently used, formed the only basis of comparison available to us. He did not see as yet any scientific reason for casting them overboard.

Mr. J. H. Narbeth suggested that it might be possible to follow up the paper by carrying out some experimental investigations, and to fit up a sort of seismograph which would measure the accelerations at the middle of the ship as she rose and fell when passing over big waves.

Mr. E. F. Spanner asked what figure the author had allowed as a corrosion margin in arriving at the effective area of material on which he had worked out the stress calculations. That was important, having in view the higher classes of steel which were coming into use. He asked if the author, in analysing the various cases, had taken account of the effect of water pressure on the bottom. It seemed to him that if the holds were loaded the weight on the bottom plates would be balanced by the weight of the water outside, but, where there was no weight inside, the stress would be much greater, owing to the pressure of the water outside.

Mr. Foster King, in a brief reply, said his object was not to advance a theory, but merely to state that the figures which had been used for thirty-seven years had been a sound guide up to a point. He had simply stated that here was a factor which agreed with the observed results of damaged ships under known conditions of loading in a way which the ordinary calculations on the basis of the known loads did not satisfy. He intimated that he would reply fully to the discussion in writing.

The Chairman, proposing a vote of thanks to Mr. Foster King, said the paper was an important one, and embodied the author's life experience. The fundamental thing about the question, as he understood it, was that there was the support which was given to a ship by the buoyancy of the water, and there was the downward pressure given by the loading, and it was the difference between the support and the loading that caused a bending moment on the ship. If it were possible to arrive at some short method of determining what, under all circumstances, the relation between the loading and the support would be, a great benefit would be conferred upon naval architects.

The vote of thanks was accorded with acclamation, and the meeting adjourned until Thursday.

The first business on Thursday morning was the reading and discussion of a paper by Engineer-Captain Turner entitled "A Note on Experimental Diesel Engines." This paper is reproduced in an abridged form on page 383.

Experimental Diesel Engines.

The discussion was opened by Engineer Vice-Admiral Sir George Goodwin, who, as one interested from the beginning in the establishment of the Admiralty Engineering Laboratory, paid a tribute to the staff of that institution for the advances it had made in the development of the special types of engines required mainly for naval purposes. Sir George then referred to the development of the Digit engine, the development of which was undertaken after preliminary work carried out at South Kensington, the notion being to get a much higher power than had been obtained in engines of that type during the war. That engine had achieved success and was being utilised in ships at sea and was running very well, he believed. The results in connection with the Datic engine, and the development of the 2000 I.H.P. cylinder, were really wonderful, and could not have been achieved, except in a laboratory belonging to the Admiralty. Dealing with the author's table in which the powers that could be obtained with the various types of engines were compared, it showed, he said, that a two-stroke double-acting engine could develop only double the power of a four-stroke single-acting engine of the same dimensions under similar conditions of charging, and he expressed the hope that the author did not expect his audience to accept that as applying to types of engines other than those described in the paper, because much greater improvements had been obtained in many cases. He would have preferred also, he said, that the snap test figures relating to the Datic engine had been left out of the paper; he hated snap tests, because he had known cases—many years ago—in which snap test results on steam engines were made the basis of design. More work was required in regard to pulverisation, which we had not progressed anything like far enough. A paper from the Laboratory, dealing with the injection of fuel by spraying, had been most valuable, and had formed the basis to a very large extent of later work which had been done on Diesel engines in that connection. Finally, Sir George asked for further information as to the difficulties the author had mentioned in connection with aluminium pistons and how they were overcome, and also as to the torsional oscillations, their extent and how they were measured.

Engineer-Commander Tostevin, as one who was at the Admiralty Engineering Laboratory for a period prior to Captain Turner, also paid a tribute to the staff and said that the results achieved there had placed the Laboratory in the forefront in regard to experimental work on Diesel engines. Great care had had to be exercised in working up the Datic engine in the early stages. When he had left the Laboratory the power reached was about 1350 H.P., but there had been trouble with the aluminium pistons. The trouble was that aluminium pistons of the size used had to be made fairly thick; they would not stand up to the rapid fire bombardment, and, the construction of the pistons being rather special, there were certain expansion difficulties. In all engineering work one usually associated reliability with simplicity, and, naturally, a rather simple design of piston was adopted at first. The experiments had shown, however, that that would not do, and a more complicated structure was found to be necessary. There was no doubt that, in order to obtain over 2000 I.H.P. in a double-acting cylinder working on the two-stroke cycle, it was necessary to have very large accessory power. It was necessary to have quite a big supply of blast air and quite an ample supply of high-pressure scavenge air, and it was seen that the I.H.P. of the pumps, when the power line was developed to 2000 I.H.P. was something of the order of 22 per cent., *i.e.*, if one imagined a six-cylinder engine of the Datic type relieved of all its accessories, 12,000 I.H.P. would be developed by the power line and about 10,000 on the brake; but pumps which themselves required something like 2500 I.H.P. had to be used. They would consume something like 3500 B.H.P.—say, 4500 to 5000 I.H.P. in Diesel engines—to drive them. Of course, the efficiency of that combination was naturally low, and he imagined that the weight of the installation would be considerably greater than that of a modern steam-driven plant of the type fitted in a battleship, and the efficiency would not be much better, if anything at all, than that obtained with the modern steam-driven plants. Those facts needed to be appreciated, in case one were carried away by the very fine results achieved in regard to the power obtained from the power cylinder. The remarkable gain in efficiency resulting from the alteration of the arrangement of the supercharge and scavenge air reservoirs was worth noting. The fact that large accessory power was required for the two-cycle engine had given him a leaning towards the four-cycle double-acting type, and he was pleased that an engine of that type was now under test at the Laboratory. Having in view the disadvantages arising from the large accessory powers, if perfect combustion could be obtained with mechanical injection, it would be a great step forward.

The discussion was continued by Engineer-Commander Hawkes, who also was associated with the Admiralty Engineering Laboratory in the early days. Speaking of the double-acting Datic engine, it was not, he said, designed for any very definite purpose, but was an experimental engine from which to obtain information. In considering the design he had come to the conclusion that, if anything like success was to be achieved in large powers, particular attention must be paid to the question of the combustion of the fuel, and he had proposed to build an engine round a combustion chamber of comparatively good shape, as had been done. The results given in the paper appeared to show that it had more or less justified itself; the mean pressures were comparatively high, and he did not think that such pressures had been obtained by many other engines of that speed. Scavenging was inefficient, he considered, and no doubt more attention would be paid to it. Table II., relating to the Datic engine, showed that the scavenge air pressure and the supercharge air pressure were the same throughout. The idea had been to split up the two charges of air—that required for scavenging the cylinder and that required for supercharging—for experimental purposes, but inasmuch as those pressures were shown to be the same throughout, it was, he supposed, decided that it was not worth separating the two. It might not be satisfactory for engines of comparatively high speeds. Some supercharging results on the Digit engine did not appear to fit in. The induction air was given in terms of cubic feet per minute, and he asked how the volume was measured, because later on in the paper an estimate was given of the normal volumetric efficiency of the cylinder, and it was stated that that estimate was confirmed by a number of tests with light spring diagrams. He did not think that any body could obtain the volumetric efficiency with a light spring diagram, because that diagram gave volume only and not temperature. Probably, better results would be obtained with a more efficient blower, and also as the result of fitting coolers for cooling the scavenging air. It seemed also that the sprayer needed attention, and it was probable that better results would be obtained by reducing the compression ratio. The problem of whether the provision of the additional plant necessary for supplying the supercharging air was worth while had to be considered in relation to each particular case, but he did feel that the best engine for submarine propulsion was the single-acting four-stroke trunk piston engine. Probably it would be worth while supercharging. He was glad the author had emphasised strongly the importance of combustion in relation to the wear of liners, for he felt that everything depended on combustion in this engine.

Engineer-Captain Turner replied briefly, and intimated that he would deal with the bulk of the criticisms in a written reply. As to the suggestions that experiments on spraying had apparently been neglected, he said it must be remembered that it was of no use spraying unless there was an atmosphere of pure air to spray into, and the trouble during the past few years had been to get an atmosphere of the kind in the cylinders; therefore, the spraying experiments were necessarily delayed. In reply to Engineer-Commander Hawkes, he said the supercharge and scavenge systems were entirely separate. The L-shaped piston ring was used, not for the purpose of trying a broad ring pure and simple, but with the sole object of reducing the bearing pressure on the liner, and to see whether, by reducing the bearing pressure by, say, 50 per cent., the wear could be minimised.

The next paper taken was one by Mr. E. H. Mitchell, on "The Design and Propulsion of Fast Double-ended Screw Vessels." The following is a short synopsis of this paper.

DOUBLE-ENDED SCREW VESSELS.

This paper deals with the design and propulsion of fast double-ended screw vessels, special reference being made to the fleet of ferry vessels of this particular type employed in the Sydney Harbour service between Sydney and Manly. In this service six vessels are operated by the Port Jackson and Manly Steamship Company, and the paper has special reference to the two passenger vessels "Dee Why" and "Curl Curl," which were designed last year by the author and were built by Napier and Miller, Ltd., of Old Kilpatrick. These ships have a length of 200ft. with a breadth moulded of 35ft. 11in., a depth moulded to main deck of 15ft. 6in., and an extreme draught of 12ft. 6in., with a gross tonnage of 799. The propelling machinery is of the quadruple-expansion type, made by D. and W. Henderson, Ltd., and works at 185 lb. boiler pressure at 160 r.p.m. The valve gear is arranged to give the same power ahead and astern. In an appendix a full description of the hull and machinery is given, along with drawings. The author discusses the propulsive efficiency of double-ended ships, and in a table in the first appendix tests made in open water at the William Froude National Tank, showing the efficiency of a screw thrusting with the back, are reproduced. Although the trials of the ships referred to have added to the knowledge of the efficiency of bow propellers working in conjunction with a stern propeller on the same shaft, the author considers that further information is required as regards the wake factor, the thrust deduction factor, and the hull efficiency of a bow propeller working in place by itself, as compared with the corresponding efficiency of a stern propeller.

Mr. Hamilton Gibson, opening the discussion, referred to some broad-beamed luggage boats propelled by twin engines operating screw propellers at both ends, which had plied on the Mersey some thirty years ago, and said he understood that the bow screws were found to be useless, and in consequence were removed. It could readily be understood that the retarding effect of the propeller race upon the bows of a bluff vessel would be considerable. In 1910 he had been responsible for the machinery design of a double-ended ferry steamer for Cuba having a single continuous line of shafting, driven by a two-cylinder compound engine of 900 H.P., the speed of the vessel

being 11 knots. Two thrust blocks had had to be fitted, one forward and one aft of the engines, and special adjustments had had to be made to ensure that both blocks did their fair share of work. If that were not allowed for the thrust or pull of one or other of the propellers imposed a corresponding strain on the webs of the crank shaft, which was very undesirable. Differences of temperature affected the adjustments, and those differences would be more marked in a longer engine, such as the four-crank engine described in the paper. He asked Mr. Mitchell how the difficulty had been met in the vessels he had been concerned with.

Professor P. A. Hillhouse said Mr. Mitchell had claimed that in the propeller working at the bow the wake factor was lost; no doubt it was to a large extent, but there would be some amount of wake, so that although there was a loss in hull efficiency owing to reduced wake, there was also a gain in the propeller efficiency in the open. It was unfortunate that the tables gave only the efficiency of the propeller working in the open and did not include the wake, thrust deduction, and relative rotative efficiency.

Mr. H. M. Napier, referring to the two boats mentioned in the paper, said the owners wanted to get too much into the boats and had tied the designers down with regard to beam, and had it not been for the strong recommendation of those concerned with the experimental tank, he doubted whether the owners would have been persuaded to allow an increase of another foot on the beam. Another difficulty was to make the rules and regulations which had applied in the past in Sydney Harbour fit in with the modern British Board of Trade requirements. The preliminary trials on the boats were carried out on March 27th, so that there had not been time to analyse the results fully. Although there had been various prognostications that the guaranteed speed would not be attained, at the preliminary trials more than the guaranteed speed had been attained with the engines developing considerably less than their full power, and he did not think there would be any difficulty in the engines developing their full power—another four or five revolutions, probably.

Mr. M. P. Payne said that in vessels fitted with a propeller at each end the forward screw would absorb less power than the after screw. That was borne out by the figures quoted in the paper, with the exception of those referring to tests with propeller blades equally curved on the back and face, when the power was stated to be fairly evenly distributed between the two screws. This latter result was rather surprising, in view of the conditions of working being identical, with the exception of wake, and seemed to suggest that the difference in wake at the screws was not as great as 15 per cent.

Mr. Mitchell, replying to the discussion, referred first to the Mersey ferries mentioned by Mr. Gibson, on which the bow screws were found to be ineffective, and said that the conditions on the Mersey were totally different from those which would have to be met by the boats described in the paper. Owing to the strong tide in the Mersey it was necessary for vessels to turn round quickly, and the position of the piers had also to be considered; no sane naval architect, in his opinion, would suggest that under Mersey conditions double-ended vessels should be used. There might be some wake at the bow of a double-ended vessel, but he did not think it had ever been measured. The boats he had described were extremely fine and the screws well advanced, so that there could not be much wake. The preliminary trials had shown that a speed of 17 knots would easily be exceeded.

In the middle of the morning meeting a bust of the late Sir Philip Watts was unveiled by the Rt. Hon. Winston Churchill.

Sir John Biles outlined the history of the movement to provide this bust. Those who had known and loved Sir Philip Watts, he said, had thought it very desirable that some memorial to him should be created, and they had asked the Presidents of five societies with which Sir Philip was associated if they would help. Those societies, in the order of their age, were the Worshipful Company of Shipwrights, the Royal Society, the Smeetonian Society of Engineers, the Institution of Civil Engineers, and the Institution of Naval Architects. The Presidents of those bodies had promptly supported the movement and a committee was formed, to which each body had appointed one person. The committee had then asked the members of the various bodies to support the movement, and as a result collected a fund sufficient for the purpose of obtaining a bust, which was made by Sir John Angel, had been collected. The committee had decided that the bust should be entrusted to the Institution of Naval Architects, and had asked the Chancellor of the Exchequer if he would be good enough to perform the ceremony of presenting it on behalf of the subscribers.

The Chancellor of the Exchequer said that Sir Philip, like so many of the leading figures of his time, had risen to a position of high consequence, and of even vital significance, in the State and in the Empire, from humble beginnings. He had begun to work at the Admiralty after the "King Edward" class, with their mixed armaments, their museums of guns of various patterns, had been superseded by the more heavily armed "Lord Nelson" class, which he designed himself. The transition to the all-big-gun ship, probably the most famous ship of war ever built—the "Dreadnought"—was the next step which, under the impulse of Lord Fisher, Sir Philip was responsible for taking. Sir Philip had probably designed more of the great ships which had fought in war than any other naval constructor. The whole of the earlier "Dreadnought" class and the Super-Dreadnoughts, down to the "Queen Elizabeth" period, which had constituted our fleet at the outbreak of war, were his design, and his model was imitated as fast as possible by every other navy in the world. All who had worked under him had felt that they were serving a chief who was not only master of his subject, but who was anxious that his knowledge should be imparted to and shared by those who had surrounded him and had worked with him. It was his practice to give very important work in designing problems to subordinates, and sometimes to junior subordinates, and then to review that work with them, thus associating them with the completed task, and there was no doubt that when, after his long service, he had left the Admiralty and had handed over his duties for the culminating period of pre-war preparations to Sir Eustace D'Eyncourt, he had left behind not only a reputation unsurpassed in the Corps of Naval Constructors, but a band of firm friends and admirers among those who had known him best and who were best able to appreciate his qualities and gifts. In the name of the subscribers he presented the bust to the Institution of Naval Architects in the confidence that it would long be guarded and honoured in the Institution and would preserve the memory of Sir Philip Watts as one of the greatest, if not the greatest, of the constructors of warships in the period of the world's greatest war.

(To be continued.)

Bending and Loading of Ships.*

By Mr. J. FOSTER KING.

In this paper the author sets forth reasons for introducing a modification into the "standard" formula for maximum bending moments to be expected in actual service conditions, which is of the form $L \times B \times d \div 35 \times 0{\cdot}043\,L$, where L = length, B = moulded breadth, and d = moulded draught. Some modifications are regarded by the author as necessary to meet the different and more severe service conditions which are encountered in ships of modern design, with modern models and modern dispositions of load. Cases are referred to in which ships have suffered structural damage on ballast passages, although the calculated wave crest bending moments at ballast draught were less than the standard. Again, passenger ships of fine form have given indications of being subjected to sagging moments which exceeded the standard, while in ships designed for heavy trades the actual moments have exceeded the calculated moments. The author's view that the standard bending moment may not give sufficient value to the dynamic effect and that limits of loading should be associated with it was strengthened by full-scale loading experiments made on the Holt ship "Prometheus." In these experiments the ship was subjected to a hogging stress in still water which exceeded 5 tons per square inch as measured by the strain meter, and light parts of the hull structure showed such movements as are attached to the phrase "straining in a heavy sea."

Although an attempt was made to attach values to varying dispositions of load by means of calculations of particular load variations upon varying forms of ships, it was not found possible to obtain a satisfactory general knowledge of the problem, and a complete series of wave crest calculations were made under apparently ideal conditions where the curves of load and displacement in still water were identical in form and area. It was decided to select three widely differing types of models, of which 'midship sections are given in the paper. Y model had rectangular sections, angular water lines and a 'midship coefficient of 1·0. S1 had modern lines and a 'midship section of 0·975 coefficient such as is now found over a wide range of c values. S2 had old-fashioned fine lines, hollow at ends, with a 'midship section coefficient of 0·84. The lines of each model were pulled about in order to cover c values between 0·5 and that of its 'midship section. The still water displacements were considered in relation to those on trochoidal waves which had a length = L and a height = 0·05 L, first with the crest amidships and second with the hollow amidships. In the paper the results of the calculations made from these models are given in the form of curves on a basis of block coefficient. The curves show (1) the longitudinal travel of centres of gravity of half-wave displacements about centres of gravity of half-displacements in still water; (2) the longitudinal travel of centres of gravity of half-wave displacements about centres of gravity of half-displacements in still water; (3) the vertical travel on waves; and (4) the combined longitudinal and vertical travel effect.

Dealing with the practical application of the investigations the author goes on to say that experience seems to prove that the x curves for ballast draught are a more severe measure of the movement of wave-displacements past load centres than is necessary for good service conditions, because the direct use of x travels would obviously restrict the position of the centres of gravity of the half-loads to that which coincides exactly with the ideal position, or midway between the travels of the half-wave centres of gravity. Experience also shows that the "Smith" correction (which is, in effect, a modification of wave contour) has justified its use. The effect of this modification is stated by Sir John Biles to represent a reduction of about 12 per cent. from the total bending moment derived from the unmodified wave contour, a reduction in total effect of load and wave travel which means a larger reduction in the constant travel effect of the half-waves alone. Experience also indicates that the "standard" bending moment (which corresponds to a travel equal to 0·043 L in the nomenclature of the diagrams) provides a sufficient margin to cover a movement of the half-load centres of gravity on either side of the ideal position, which is of the order of 0·01 L. It seems safe, therefore, to deduct 0·01 from the standard figure of 0·043 L and to use 0·033 L at 1·0 coefficient, as a sufficient measure of the constant bending effect of wave travel about the ideal position for the centres of gravity of the half-loads, which, as already shown, lies outside the position of the still-water centres of half-displacements by an amount which corresponds to $\frac{(1-c)\,L}{100}$. For use with the whole displacement 0·033 L becomes 0·0165 L.

As the derivation of a load factor in the "standard" formula was the chief object of this investigation, it appears on the evidence of observed facts and of the investigation that a satisfactory expression of present knowledge will be given by the following adjustment of the "standard" formula:—

Where the designed draughts bear a reasonable proportion to the length of the ship and the total distance between the centres of gravity of the half-load situated on each side of the true centre of buoyancy is equal to the total distance between the centres of gravity of the still-water half-displacements on each side, plus a distance equal to $\frac{(1-c)\,L}{50}$, the constant bending effect of wave travel at the designed draught is found from the formula $L \times B \times d \times 0{\cdot}0165\,L \div 35$, *i.e.*, the parallelepipedon displacement $\times$ 0·0165 L.

Where the whole distance between the centres of gravity of the half-loads is greater or less than that defined above for the ideal position the factor 0·0165 is to be increased by the amount derived from the following formula:—

$$\frac{\text{Difference in distance}}{4\,L} \times \frac{\text{Actual draught}}{\text{Design draught}} \times c.$$

The presence of draught and coefficient in the second or load effect portion of the formula is required because the load effect of travel varies directly as the displacement and the formula as applied gives a modification in the direction indicated by the investigation at two-thirds of the designed draught.

The formula has been tested over a wide range of known cases and gives results which harmonise more closely with observed facts than those given by the classic "wave-crest" calculations. For instance, it gives a greater bending moment than the "standard" bending moment in cases where trouble was caused by excentric loading, and the classic wave-crest calculations showed that there was no reason for it. It also gives results which could be accepted as a guide to the strength required for the "Prometheus" if sent to sea under the extreme conditions of loading to which she was subjected in still water. Above all, it gives due prominence to the importance of those loads which induce "sag" in still water.

As the formula deals only with known conditions which are easily ascertained at designed and light draughts, it enables builders to supply owners with guidance as to permissible dispositions of cargo and ballast, without having resort to complicated calculations. This in itself would be an immediate, definite contribution to the safe handling of ships, while the tangibility and relative facility of application of the method present opportunity for the expansion of knowledge of the true relation between the formula and the facts of service conditions. It would be a comparatively simple matter to provide shipmasters with information and material which would enable them to record facts as to dispositions of load in relation to positions of centres of gravity and of their effects at sea.

* Institution of Naval Architects. Abstract.

BOOKS OF REFERENCE.

"'Hutte' Des Ingenieurs Taschenbuch," Vol. IV. Wilhelm Ernst und Sohn, Wilhelmstrasse 90, Berlin, W. 66. Price 15 marks.—This fourth volume of the jubilee edition of "Hütte," prepared under the direction of the Akademischen Verein Hütte EV Berlin, represents a new departure, inasmuch as it contains a complete survey of the principal German industries, with appropriate technical particulars and information relating to each trade. In the first section of the book the transport industries are dealt with and the four chapters are devoted to shipbuilding and naval architecture, marine engines, turbines, and boilers, the motor car industry and aeroplanes and their equipment. There then follows a second section dealing with the mining industry in its broadest phases, including transport and the milling of mineral material and preparation of cement, chalk and gypsum. The third section deals with agriculture and its buildings and machinery. In the fourth section the food preparing and allied trades are dealt with, and there is a concluding chapter on cold storage. Other sections are devoted to the technical aspects of forestry, the leather trades, paper making and fibre production, including the manufacture of artificial silk, and the many associated processes, pottery and glass, and the gas industry. There are also sections on the technical sides of printing, film production, and wireless telegraphy and telephony, while a final short section, the thirteenth, deals with recent developments in packing machinery. In all there are some 834 pages, which are excellently illustrated and contain much useful tabular matter. There is a complete index to the volume, which can be thoroughly recommended to all who wish to follow the recent progress made in German technical development. The third volume of the jubilee edition will shortly be published, and will complete that edition.

A new type of coal wagon has been brought into use in Germany for conveying coal from the mines in Upper and Lower Silesia and the Ruhr to the gas and electricity works of Berlin. The wagons are constructed of silicon-steel, carry 60 metric tons of coal, and have a tare weight of 19 tons.

NEW PUMPING PLANT FOR THE DEARNE VALLEY WATER BOARD

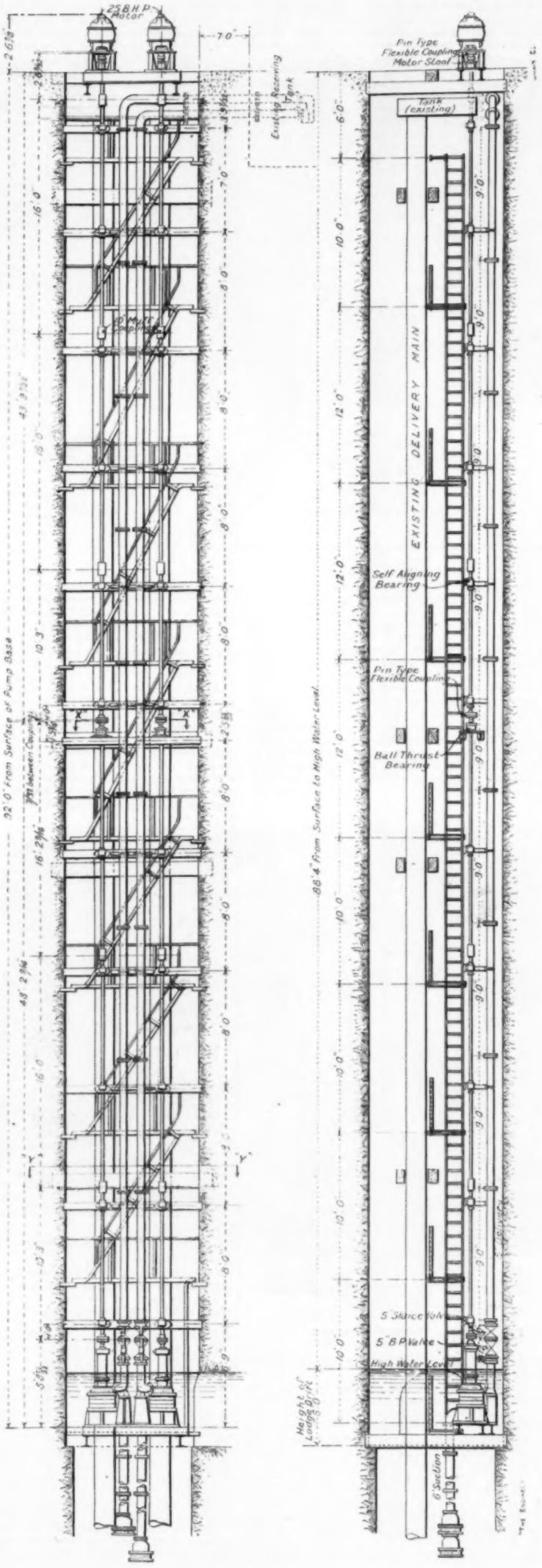


FIG. 1—SECTIONS OF WELL AT EVERHILL PUMPING STATION

New Pumping Plant for the Dearne Valley Water Board.

AN interesting piece of engineering work has recently been carried out by the Pulsometer Engineering Company, Ltd., of Reading, at the Everhill pumping station, near Wombwell, of the Dearne Valley Water Board. The station is small when compared with many others, but the work of installing some new machinery in an existing well, half the cross-sectional area of which was already occupied, necessitated the overcoming of difficulties of considerable magnitude.

The station was originally equipped with steam plant which was put to work some forty years or so ago. The

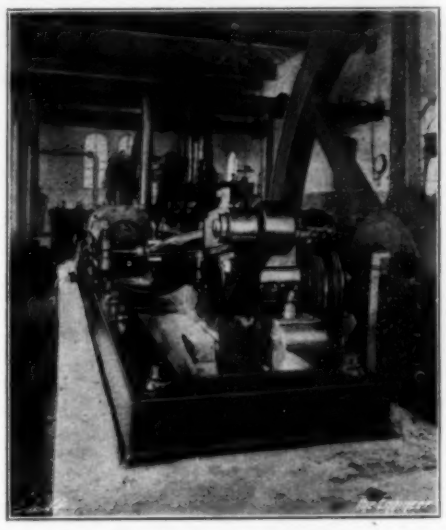


FIG. 2—OLD HORIZONTAL PUMPING ENGINE

well pumps, which were operated by spears driven by a bell crank motion from a horizontal steam engine, made seven strokes per minute. The surface force pumps, which were of the ram type, made twelve strokes per minute. They were driven by the same engine. Two views of the old engine-room are given in Figs. 2 and 3. When first erected, the old plant was, for its period, of an excellent character, and during its lifetime it is credited with having pumped some 4000 million gallons of water—which works out at the rate of something like 460 gallons per minute for ten hours a day continuously—from a deep well, the ordinary standing water level in which was some 84ft. from the surface, and having lifted it thereafter against a total head of 885ft. But it was wearing out, and it was inefficient when considered beside modern pumping machi-

FIG. 3—OLD ENGINE AND FORCE PUMPS

nery, so that some eighteen months ago it was decided to replace it.

Now, it was impossible to dismantle the old plant and remove the delivery pipes from the well until the new plant was got to work because the water was needed, and because it was necessary to keep down the water level in the well while the new plant was being fixed. Hence, it was necessary to erect the plant in a very confined space, and that, as has been said, presented a good many difficulties, not the least of which was the fact that, whereas the ordinary standing water level in the well was some 84ft. from the surface, actually, when the new pumps and gear came to be installed, it frequently rose as high as to within 45ft. of the surface.

The well shaft is 9ft. in diameter and practically half its cross-sectional area was occupied by the existing beams and pipes. That only left, therefore, a semi-circular

space, the greatest width of which was only some 4ft. 6in., in which to erect the new gear. The specification called for the supply of two well pumps, each capable of delivering 250 gallons of water per minute against a total head of 140ft. The pumps which the Pulsometer Company decided to install were 5in., four-cell vertical-spindle machines, designed to run at 960 revolutions per minute, with a guaranteed efficiency of 72 per cent. and a toleration of ± 2 per cent. They were ordinary stock machines, and do not call for any special mention, but they had an overall width of 2ft. 5in., and, with the best arrangement of suction and delivery pipes that could be devised, the space occupied in a horizontal plane could not be made less than some 6ft. 4in. long by just a shade under 4ft. wide. The

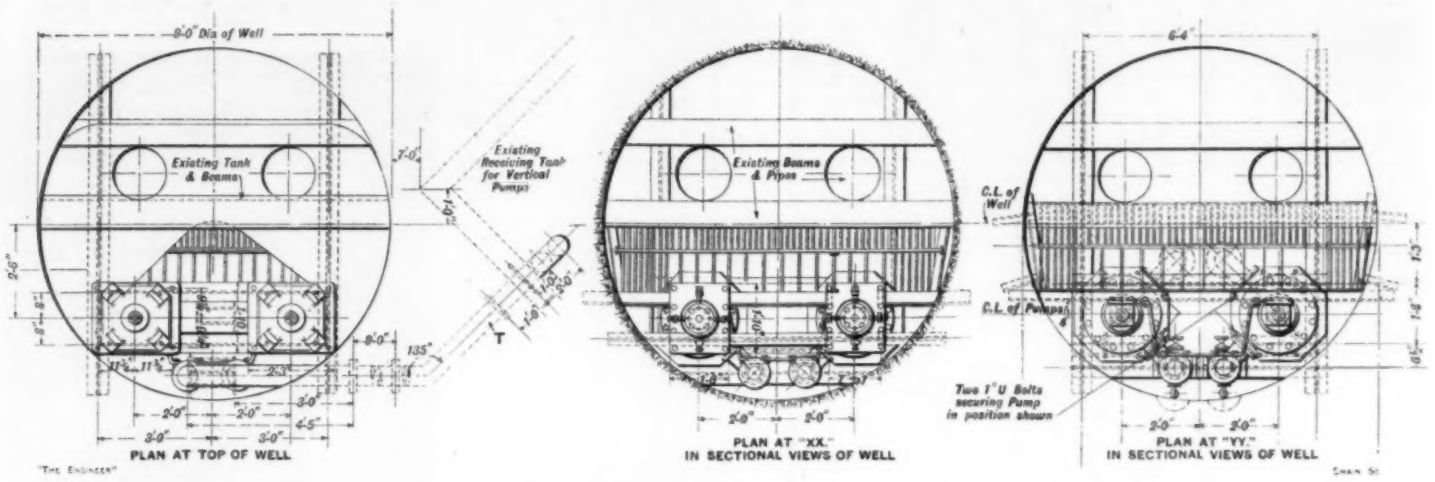

9'-0" Dia of Well
Existing Tank & Beams
Existing Receiving Tank for Vertical Pumps
PLAN AT TOP OF WELL
Existing Beams & Pipes
PLAN AT "XX." IN SECTIONAL VIEWS OF WELL
C.L. of Well
C.L. of Pumps
Two 1" U Bolts securing Pump in position shown
PLAN AT "YY." IN SECTIONAL VIEWS OF WELL

FIG. 4—PLAN AT TOP, AND SECTIONAL PLANS OF WELL

total weight of the pumps, suction and rising mains, and driving shafts, together with the water in the mains, was in the neighbourhood of 8 tons. To carry it, it was decided to employ rolled steel joists let into the wall of the well.

The well shaft had been sunk through red sandstone rock. For the first portion of its depth the shaft is lined with stone blocks, but lower down there is no lining, and in many places water entered in spurts, which increased in volume at greater depths, so that at the bottom there was something approaching a continual downfall of heavy rain, which was increased by jets of water coming from the barrels and shootings of the old pumps where they had been eaten away with rust and age. To fix the joists, holes had to be cut by hand in the rock by hammer and chisel, the material to be dealt with proving to be nearly as hard as metal. When the work was begun, the only way of getting down the shaft was at the first by the use of what was euphemistically called the "chair," but which was, in reality, a small half-moon-shaped wooden platform hanging by three chains from a single winding rope. The

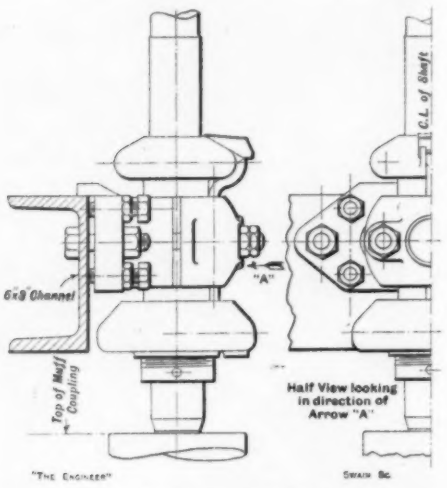


FIG. 5—PUMP SPINDLE BEARING

only illumination available was obtained from hurricane lamps, for electric light had not, in the first instance, been installed.

The difficulties were increased by the following factors:—(*a*) All work in the first instance had to be done sitting in the "chair"; (*b*) it was by no means easy to work to a plumb-bob hanging on a 100ft. line, especially as, not infrequently, a blob of rusty-coloured water would trickle down on the point of the bob; (*c*) there was no secure foothold anywhere, since everything, including the existing pipes, was covered with slime, and, lastly (*d*) as there was no efficient means of ventilation, the atmosphere at the bottom of the shaft became very oppressive as the day wore on. Furthermore, in spite of being clad in oil-skins and wearing sou'-westers, and high rubber boots, those engaged in the operations speedily got drenched to the skin. It is hardly to be wondered at, therefore, that the first holes to be cut—which were those to receive the joists on which the pump platform was to be formed, and which were cut before the Pulsometer Company's engineers arrived on the spot—were found, when they came to be investigated, to be in some cases from 3in. to 4in. out of their correct positions! However, this matter was eventually put right, and all the holes were cut successfully, though, in some cases, fissures were broken in upon during the process, with the result that there were gushes of water, some of them of considerable volume, which added to the general discomfort and difficulties of the job. A point worth recording, however, is that the result of cutting these holes has been to increase the volume of water which it is possible to draw from the well.

At a depth of some 90ft. from the surface two horizontal drifts or adits had been driven from the well shaft opposite to one another. These drifts were 5ft. wide and about 5ft. high to the undersides of their domed roofs. It was decided that the lowest sustaining girders should be fixed with their undersides at the same level as the floors of these drifts. Two rolled steel joists, 10in. by 6in. by 9ft. 9in., were accordingly fixed across the shaft at about 6ft. 6in. centres—see Fig. 1 and the plan views given in Fig. 4, which are taken on the planes indicated in Fig. 3. On these joists were bolted at right angles three further joists, 8in. by 6in. by 6ft. 6in., arranged parallel to one another, and it was on the latter that the pumps were fixed. The 6in. suction pipes with foot valves and strainers at their lower ends, depended from the pumps further down into the well, one being taken down 22ft. and the other some 2ft. lower. Two channels are fixed below the main joists which carry the pump and the weight of the suction pipes is carried from those channels by means of clamps round the pipes. The main flow of water into the well shaft is through the drifts or adits, and, in order that the new pumps might be fixed, it was necessary, as has been

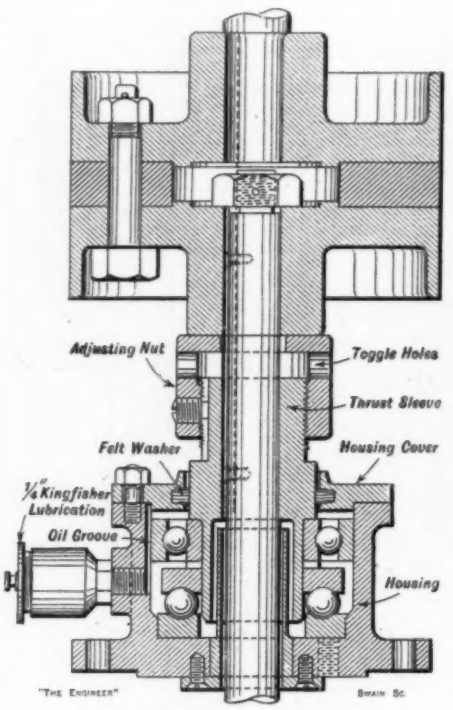


FIG. 6—BALL THRUST BEARING

said, to work the original pumps so as to keep the level of the water sufficiently low.

The spindles by which the new pumps are driven from motors at the surface, and which are of rustless steel, 2¼in. in diameter, are carried at intervals of 8ft. in self-aligning bearings, which are bolted to 6in. by 3in. by 9ft. 9in. channels, arranged on edge, the ends of which are let into the sides of the well shaft. A drawing of the bearings showing the method of fastening them to the channels is given in Fig. 5. Dependence is not placed on packing pieces, but the bearing can be put into proper position by means of set screws which bear against the channel. When adjusted in correct position, the base of the bearing is held firmly against the channel by through bolts. The shafting in the case of each pump is connected by a rigid coupling to the top of the vertical pump spindle, and it is divided in the middle of its length by means of a pin-type flexible coupling, which comes at such a height in the well as to be considerably above the level to which the water can rise. Immediately below this coupling is a ball thrust bearing, which is carried on two 6in. by 4in. joists, and which supports the weight of the lower half of the shafting and of the impeller of the pump. The arrangement of the bearing is shown in Fig. 6. It will be observed that it embodies a ball journal bearing as well as a thrust washer. The upper half of the pump spindle is connected to the lower end of the motor spindle by means of a pin type flexible coupling, and its weight is taken by a thrust bearing at the end of the spindle. The various lengths of spindle are connected together by muff couplings. The thrust bearing immediately above the pump is an ordinary thrust bearing with *lignum vitæ* pads bearing on a gun-metal face. It is water lubricated, because it is liable to be flooded. The steady bearings on the vertical spindles were, for as high up as the water was liable to reach in the well, also furnished with *lignum vitæ* strips, and arranged for water lubrication when the water in the well did not reach them.

At the bottom of the 5in. delivery pipes, which are flanged cast iron pipes in 9ft. lengths, there is, first of all, a back pressure valve, and immediately above it a 5in. sluice valve. The weight of the pipe, and of the water in it when it is full, is taken by a substantial duck foot bend, which rests on the main carrying joists already mentioned. At each bearing point of the spindles, the delivery pipes are steadied by means of a 3in. by ½in. mild steel bridge, which is bolted to the cross channel, and to which the pipes are secured by means of ⅝in. U-shaped straps. At

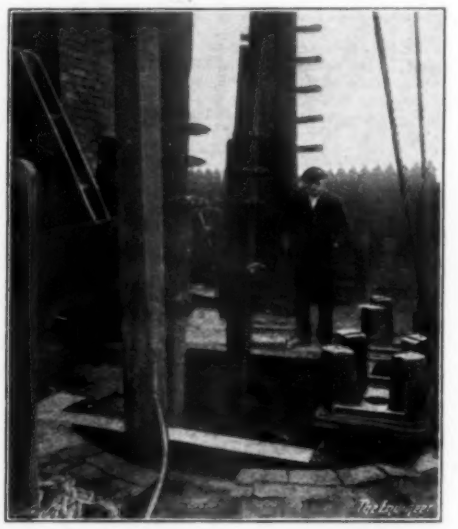


FIG. 7—THE HEAD OF THE WELL SHAFT

the top the delivery pipes discharge through right-angled bends into a tank arranged just below the ground level.

The condition of the well is very different now from what it was when operations were commenced. It is electrically lighted, and access to the bottom of it is obtained by a series of iron ladders with landings.

Some idea of the cramped situation which has been described in the foregoing may be obtained from Fig. 7, which is a view of the head of the well shaft, showing, on the left, the bell crank and spear heads of the original pumps, and on the right the stools on which the motors to drive the new pumps were to be mounted. The motors have, of course, been got into position since the view was taken. The motors, which are of 25 B.H.P., designed to run at 960 revolutions per minute, are three-phase, 50-period machines, wound for 400 volts. They were made by Bruce Peebles and Co., Ltd. Current for actuating them is obtained from the mains of the Yorkshire Electric Power Company, which, we may mention, was the chief contractor for the whole of the installation.

From the tank on the top it is necessary to pump the water against a total head of no less than 885ft. To do that it was decided to install two pumps, each of which has a

NEW FORCE PUMPS AT EVERHILL PUMPING STATION

THE PULSOMETER ENGINEERING COMPANY, LTD., READING, AND F. A. PARKINSON, LTD., GUISELEY, LEEDS, ENGINEERS

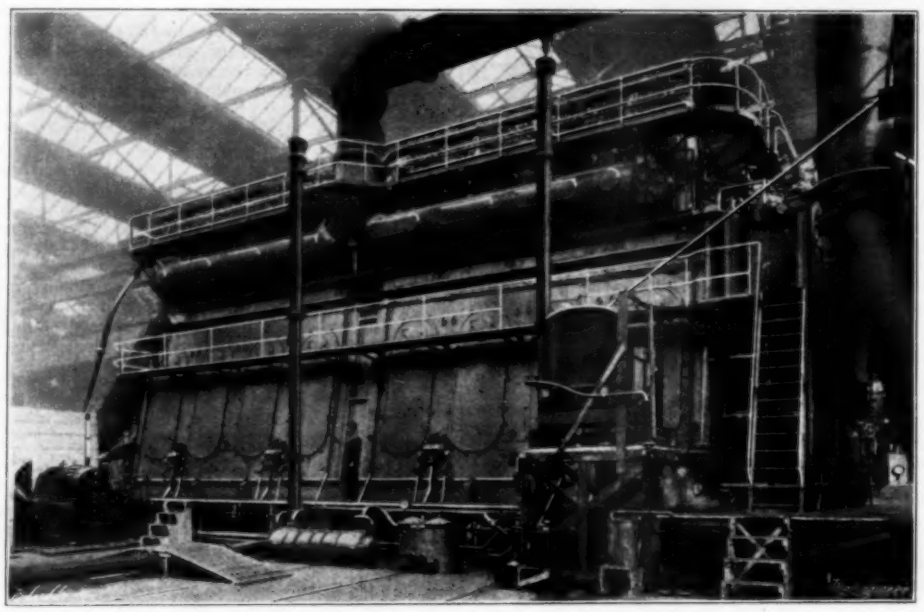
capacity of rather more than double the combined capacity of the two well pumps. For the purpose, the Pulsometer Company supplied two of its standard eight-cell, horizontal spindle centrifugal pumps, which have 6in. branches, and are designed to deliver 530 gallons of water per minute against the required head at a speed of 1470 revolutions per minute. Each pump is driven through a flexible coupling by a 220 B.H.P. three-phase, 50-period, 400-volt motor. These motors were made by Parkinson, Ltd. Neither pumps nor motors call for special mention, being all of them standard machines of their types. The necessary switch gear was supplied by George Ellison and Co. Two views in the new engine-room are given in the above engraving.

A 7000 S.H.P. Two-stroke Marine Oil Engine.

THREE years ago the Stoomvaart Maatschappij, of Amsterdam, converted its steamship "Bintang," a cargo boat of 6500 gross tons, to a motor vessel by installing in it a six-cylinder Sulzer two-stroke oil engine with a designed output of 3600 S.H.P. at 90 r.p.m. The successful operation of that vessel was referred to by Mr. S. G. Visker, the owners' superintending engineer, when discussing Sir John Biles' paper at the recent meetings of the Institution of Naval Architects. Mr. Visker's remarks are reprinted elsewhere in to-day's issue. The success of the "Bintang" was such as to lead her owners to the decision to build four fast single-screw motor vessels for their Dutch East Indies service, and these were put in hand about a year ago. The ships, which are named the "Poelau Bras," "Poelau Roebiah," "Poelau Laut," and "Poelau Tello," and which are being built in Holland, have a length of 490ft. with a breadth moulded of 61ft. and a depth of 28ft. The displacement is about 17,450 tons, which will give a deadweight carrying capacity of round about 12,000 tons. These vessels, which are designed for a service speed of about 14½ knots, will be some of the largest cargo motor vessels afloat, and they are to be propelled by Sulzer single-acting single-screw engines. At the end of last month, when the trials of the first engine took place at Winterthur, invitations were extended by the builders to visit the works and see the engine under test.

We show in the accompanying illustration a general view of the engine. It has a designed output of 7040 S.H.P. at 100 r.p.m. and the eight cylinders each have a bore of 820 mm., or about 32¼in., with a stroke of 1440 mm., or 56 11/16 in. As the engraving shows, there are two three-stage injection air compressors at the forward end of the engine. The low-pressure stages are double-acting and the two cranks are set at 180 deg. to each other, so that very good balance is obtained. The bed-plates and columns are of rigid construction and the distance piece between the cylinders and the crank case is now cast in one with the cylinder jackets. A new type of piston cooling gear is fitted, and in it the central jet pipes have been replaced by jet and pressure nozzles with an improved water catcher above the guide bushes.

The starting and manœuvring controls are neatly arranged at the forward end of the engine and near to them are the fuel pumps, which are operated by links and levers from the air compressor crossheads. The scavenge air is furnished by a single electrically driven turbo-blower with twin driving 2450 r.p.m. motors. It is of the single-stage type with a double-entry impeller and is designed for an output of 560 cubic feet of free air per second. A very complete equipment of auxiliary machinery will be installed, which includes three four-cylinder Sulzer auxiliary engines of the latest improved type. Each engine has four cylinders with a bore of 340 mm., or 13¾in., and a stroke of 550 mm., or 21¾in. The designed output is 360 B.H.P. at 180 r.p.m. and the engines are coupled direct to 220-volt direct-current generators.



7000 S.H.P. TWO-STROKE SINGLE-ACTING SULZER MARINE OIL ENGINE

The installation of the propelling machinery in the first ship will shortly begin and the vessels should enter their owners' service during the summer. Their performance will be watched with interest.

Iron and Steel Institute.

THE annual meeting of the Iron and Steel Institute will be held at the Institution of Civil Engineers, Great George-street, Westminster, on Thursday and Friday, May 3rd and 4th, 1928.

The following is a programme of the proceedings:—On the Thursday morning, at ten o'clock, there will be a general meeting of members, at which, after the presentation of the annual report and statement of accounts for 1927, and the election of new members, the newly elected President, Mr. B. Talbot, will be inducted into the chair. His first act will be to present the Bessemer Gold Medal to Mr. Charles M. Schwab. He will then deliver an address on "The History and Latest Development of the Basic Open-hearth Process." The following papers will then be presented for discussion:—E. C. Evans and F. J. Bailey, "Blast-furnace Data and their Correlation;" J. H. Jones, J. G. King and F. S. Sinnatt, "Reactivity of Coke;" T. Thomson, "The New Plant of the Appleby Iron Company, Ltd.;" and, if time permits, J. E. Holgate and R. R. F. Walton, "Blast-furnace Practice in Natal." At the afternoon session, which will commence at 2.30 p.m., the following papers will be presented for discussion:—H. J. Tapsell, "The Fatigue Resisting Properties of 0·17 per Cent. Carbon Steel at Different Temperatures and at Different Mean Tensile Stresses;" J. A. Jones, "The Properties of Nickel Steels with Special Reference to the Influence of Manganese;" A. B. Everest and D. Hanson, "The Influence of Nickel in Iron-carbon-silicon Alloys Containing Phosphorus;" and, if time permits, J. Swan, "The Effect of Silicon on Tungsten Magnet Steel;" and A. Westgren, G. Phragmén and Tr. Negresco, "On the Structure of the Iron-chromium-carbon System." The annual dinner of the Institute will be held in the Grand Hall, Connaught Rooms, Great Queen-street, W.C., at 7.30 p.m.

On the Friday, at 10 a.m., the general meeting will be continued and the award of the Andrew Carnegie Research Scholarships for 1928–9 will be announced. The following papers will then be taken:—Report of the Committee on Heterogeneity of Steel Ingots; V. Harbord, "A Comparison of the Most Important Methods Employed in the Cleaning of Blast-furnace Gas;" and W. H. Hatfield, "Heat-resisting Steels: Part II., Mechanical Properties." For the afternoon session, which will begin at 2.30 p.m., the following papers are down for discussion:—T. Swinden and P. H. Johnson, "Chromium Steel Rails;" J. Newton Friend, "A Study of the Resistance of Over-stressed Wrought Irons and Carbon Steels to Salt Water Corrosion;" W. E. Woodward, "The Rapid Normalising of Overstrained Steel;" and, if time permits, A. L. Norbury and T. Samuel, "The Recovery and Sinking-in or Piling-up of the Material in the Brinell Test and the Effects of these Factors on the Correlation of the Brinell with Certain Other Hardness Tests;" and H. O'Neill, "Twin-like Crystals in Annealed α Iron."

AUTUMN MEETING AT BILBAO.

As already announced, arrangements are in progress for holding the autumn meeting of the Institute at Bilbao, Spain. The main party will arrive on Saturday evening, September 22nd, and will spend Sunday, the 23rd, in San Sebastian. Monday will be spent in travelling by automobile from San Sebastian to Bilbao, and the meeting in that city will occupy the three days, Tuesday to Thursday, September 25th to 27th. Extended excursions will afterwards be made to Burgos, Madrid, Toledo, Sagunto, Cordova and Seville.

FOWLER'S CALCULATOR.

SOME time ago we described a very neat pocket calculator which is being introduced by Messrs. Fowler and Co., New Bailey-street, Manchester. The same firm has now brought out another instrument called the "Magnum" long-scale calculator, which is much larger in diameter and permits of all the scales of the two-dial instrument being included in one dial with longer scales, more fully graduated and easier to read than in the smaller calculator. The new calculator—the actual diameter of which is 4½in.—provides three scales on which multiplication and division can be carried out, one 13·5in. long, a second 22in. long, and a third 50in. long. The last-named scale is divided into 100 figured divisions, each of which is further subdivided by 10. The resultant accuracy of this subdivision as compared with that of the ordinary 10in. slide rule is evident from the fact that while there are only two divisions on the full-length scale of the slide rule between the figures 99 and 100, there are ten divisions on the long scale of the Magnum calculator, an advantage obvious to anyone acquainted with logarithmic methods of calculation. The new calculator, contained in a stout leather case, is not too large for the ordinary side pocket of a man's coat. The workmanship and accuracy of these instruments reflect great credit upon the makers.

The Horne Copper Mine and Smelter at Noranda, Quebec.

By the time this article appears in print the extension of the smelting works of the Horne Copper Corporation at Noranda, Quebec, will probably have begun to operate. At the moment of writing, the task of construction is nearly completed, and the buildings are receiving their final touches. This smelter plant —illustrations of which are given herewith and on page 378—is the largest mining building in Northern Canada. A concrete fume chimney, the highest in the Dominion, tops the imposing pile. Clustered around are supernumerary buildings, crusher plants, machine shops, automatic sampling plants, offices, coal blowers, shaft and hoist houses, and power houses, all of permanent construction, of steel, brick and concrete.

Both "custom" ore and domestic ore—that is, ore from the Horne mine—are to be treated at the big smelter. Separate bins are provided for each of the two classes. Ore from the Horne mine will be delivered to the receiving bin at the smelter crushing plant in the same cars in which it will be drawn from the chutes in the mine, and hoisted on cages in the main shaft. These cars, of 3-ton capacity each, will be drawn from mine to smelter by storage battery locomotives in seven-car trains. All seven cars at one time will be dumped into the receiving bin by an electrically operated rotary car dumper. Custom ore, after being weighed, will be unloaded from standard railway cars direct into the receiving bin provided for custom material.

All ores will be crushed in three stages. First, in 36in. jaw crushers to 3in. size; secondly, in gyratory crushers to 1in. size; thirdly, in rolls to ¼in. size. After crushing, each lot of ore will be accurately sampled by means of mechanical samplers, which periodically cut and re-cut the entire ore stream until a final sample is obtained, small in quantity, but of the same composition as the original lot of ore from which it was derived. This sample, after being finally ground, is assayed, and, from the results of the assay, settlement with the shipper is made. Furthermore, these assay results furnish data from which the metallurgical records are made up and chemical reactions of the smelting process controlled. After crushing and sampling, the ore will be delivered by belt conveyors to any one of the thirty-four steel storage bins, superimposed above the roasting furnaces. These storage bins have a combined capacity of between 9000 to 10,000 tons, and constitute the principal ore storage provided between mine and smelter. Their position, in the highest and warmest part of the main smelter building, precludes any possibility of trouble from frozen ore. All ores, flux and other material entering the crushing and sampling system will be automatically weighed on the belt conveyors, in transit, by means of weightometers. These weights will be used in making up the metallurgical records.

At the bottom of each of the storage bins is a steel pan conveyor, electrically-driven and delivering direct to a roaster beneath. Four, and in some cases five, of these conveyors will feed to each of the eight roasters, and the ore mixture to be roasted will be made up by adjusting the feed from the various bins. Eight wedge roasters will be provided, and each will have a capacity of from 100 to 150 tons of ore per day. The roaster consists of a cylindrical steel plate shell, 25ft. in diameter and 27ft. high, lined with refractory brick, and containing seven self-supporting fire-brick hearths, built around a central revolving shaft. The shaft carries two arms at each hearth, and to these arms are attached rabbles, which rake the ore from hearth to hearth. Power to revolve the shaft is supplied through gears from an electric motor beneath the roaster.

The ore, falling from hearth to hearth, meets the ascending current of air, which furnishes oxygen for the oxidation of sulphur and iron. With a sulphur content of 25 per cent. in the incoming ore, and roasting it to a sulphur content of 10 per cent., sufficient heat will be generated for the roasting operation to be carried on with little or no extraneous fuel. The roasted ore, or "calcine," will be discharged from the roaster at a temperature of about 1000 deg. Fah., and conveyed in steel cars to the reverberatory furnaces.

The purpose of roasting is, of course, to oxidise part of the iron and sulphur, in order to control the subsequent smelting and converting operations. That part of the iron which is oxidised in roasting combines with silica in the smelting process to form slag. Unoxidised iron, with its associated sulphur, combines with copper and additional sulphur to form matte, the grade of matte depending upon the quantity of sulphur left unoxidised in the roasting process. Thus, in the reverberatory furnace, a concentration of copper and an elimination of iron and silica are effected, and a grade of matte attained which will permit of most economical conversion to copper. In the present case, when smelting a roasted ore containing 10 per cent. copper, the resulting matte will contain about 35 per cent. of copper.

The smelting process will be carried on in reverberatory smelting furnaces. These furnaces are rectangular brick structures, 100ft. long by 25ft. wide—inside dimensions. The walls are 2½ft. thick, and the arched roof 20in. thick. Walls and arch are built of highly refractory silica brick. The furnace bottom will consist of crushed silica, fused in place at the beginning of operations. The brick arched roof will be supported, independently of the side walls, by means of 15in. steel one-beam buckstays and steel tie-rods. At one end of each furnace four burners for pulverised coal will be installed. Each furnace will consume from 50 to 75 tons of coal, and smelt upwards of 500 tons of ore per twenty-four hours. A temperature of about 2500 deg. Fah. will be attained.

The charge to be smelted will consist principally of roasted ore, probably to the extent of 80 per cent. of the total solid charge. Raw ore, lime rock flux—if needed—and reclaimed flue dust will make up the balance of the solid charge, in addition to which, all the molten converter slag will be poured into the reverberatory furnaces for the purpose of settling out its contained copper.

The reverberatory furnace smelting operation yields two products, matte and slag. The matte will consist of almost all the copper contained in the entering charge, together with part of the iron and about 75 per cent. of the sulphur contained in the charge, the other 25 per cent. being eliminated in the furnace gas as a result of chemical action in the smelting process. The slag will consist of all the silica, alumina, lime and magnesia contained in the charge in oxidised form. The composition of the slag will be about 40 per cent. silica, 6 per cent. alumina, 45 per cent. iron oxide, 3 per cent. lime, plus magnesia, and smaller percentages of other minor constituents. The copper content of the slag will, it is said, be about one-half of 1 per cent.

The matte will have a specific gravity of about 4·5, and the slag of about 3·5. By virtue of this difference in gravity, the two liquids will separate into two distinct layers, and will be withdrawn from the furnace at different elevations, the slag overflowing at a point about 18in. higher than that at which the matte will issue from the furnace.

The slag will be conveyed, molten, in motor drawn steel slag pots, of 225 cubic feet capacity, to the dump, and there poured out as a waste product. The matte will be tapped into steel ladles, of 15 tons capacity, and their molten charge will be fed into the converters by means of an electrically-operated travelling crane. Two converters of the horizontal type are provided. Each consists of a steel cylinder 12ft. in diameter and 26ft. long, lined with magnesite brick. It is equipped with heavy steel riding rings and mounted on trunnions, so that it can be rotated by an electric motor. The materials charged into the converter will consist of molten matte from the reverberatory furnaces and a flux of highly siliceous, low-grade ore, ordinarily obtained from the Horne mine, but in the absence of such siliceous ore, flux for the converters in the form of barren sand or gravel will have to be used.

In the converting process, air at about 15 lb. pressure is blown through the molten matte. This air will be furnished by two reciprocating compressors, each having a capacity of 20,000 cubic feet of free air per minute. All of the iron and part of the sulphur become oxidised, the sulphur in the form of sulphur dioxide going out through the stack, whilst the iron oxide combines with the silica of the flux to form slag, which is skimmed off into ladles and poured by the crane into the reverberatory furnace, as mentioned above.

After skimming off the slag, there remains in the converter, copper sulphide, more commonly called "white metal," containing about 80 per cent. copper and 20 per cent. sulphur. Air is again blown through this liquid until all the sulphur is eliminated and only copper remains. This metal is the final product o the local operations, and will contain about 99 per cent. copper, plus whatever gold and silver may have been in the material smelted, and small quantities of such impurities as iron, sulphur, arsenic, &c. This final product, commonly called blister copper or copper bullion, will be cast into bars locally and shipped to an electrolytic copper refinery, where the gold and silver will be reclaimed and the copper refined to marketable quality.

The matte in the smelting furnaces and the matte, "white metal," and the copper in the converters, act as collectors of any gold and silver contained in the materials charged into the various processes, which fact accounts for the concentration of these metals in the final copper bullion. In the converting process, so much heat is generated by the oxidation of the iron and sulphur, plus the heat of the reaction between the iron oxides and silica, that no extraneous fuel is required. As a matter of fact, cold material has frequently to be added, in the form of ore and scrap, to hold the temperature below a point at which the magnesite lining of the converter would be damaged.

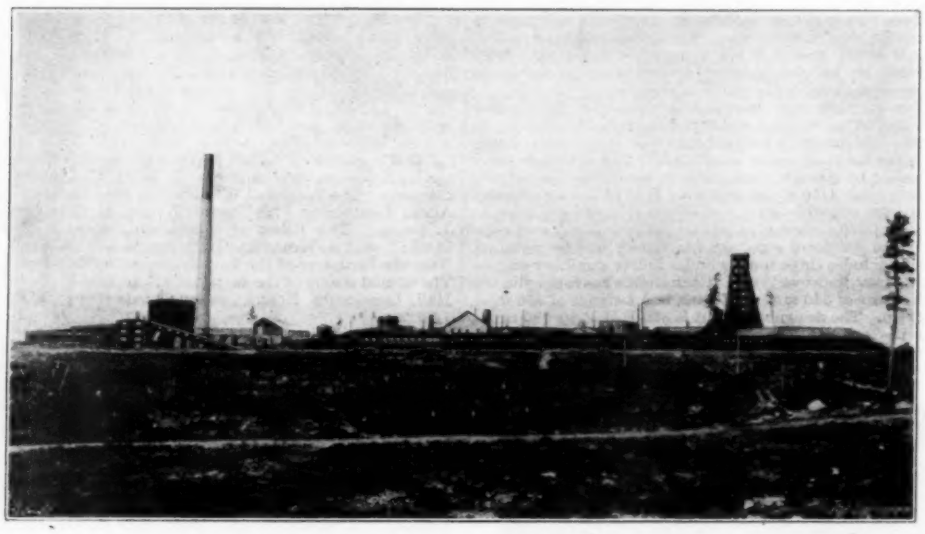
A pulverised coal plant will prepare coal for the smelting operations. Eleven cylindrical concrete silos will furnish storage for about 4000 tons of coal. After drying, the coal will be pulverised to such a degree that 85 per cent. of it will pass a 200-mesh sieve. The daily coal requirement, when running to plant capacity, will be between 100 to 150 tons. Sufficient coal can be pulverised in one eight-hour shift to supply the plant for the entire twenty-four hours. From the pulverising plant the coal dust will be conveyed in pipes by low-pressure air to the burners at the furnaces. Only one-third of the air required for the complete combustion of the coal will be used for conveying it to the burners, the other two-thirds, or secondary air, being preheated by the waste gases from the reverberatory furnaces to a temperature between 500 deg. and 1000 deg. Fah. This is a new departure in copper smelting practice, and is expected to result in a very considerable fuel saving.

All gases from the roasting, smelting and converting operations will be discharged into steel balloon flues and conducted to a brick-lined concrete chimney, 422½ft. high, which will perform two functions:—

(1) It will provide natural draught for the roasters, reverberatory furnaces and converters; and

(2) It will discharge the smelter gases into the upper strata of the atmosphere, and thereby effect very great dilution of them before they fall to earth.

According to an official announcement, there will be no immediate effort to attain tonnage records. For the time being attention will be centred on the perfection of the process. Once established on an efficient basis, the work of gradually increasing to 1000 tons, and possibly 1200 tons, daily will be attempted. For a time, all the ore going through the smelter will be drawn from the Noranda mine itself. Later, the smelter will handle ore from the big Waite-Ackerman-Montgomery property in Northern Quebec.



General View of the Mine and Smelter

After the foregoing article was set up in type we received the following additional information:—

The smelter has been producing for a couple of months or so, and officials of the company state that operations to date have been quite satisfactory. Some minor difficulties were encountered, but the performance of the plant has, on the whole, been highly encouraging. No power trouble has been experienced, and it is stated that the output has averaged about 35 tons of blister copper a day.

Railway Matters.

Sleeping accommodation for third-class passengers will, apparently, shortly be available, seeing that when the King of Afghanistan visited Swindon the other day there was displayed the first completed section of one of the G.W. new carriages.

At a meeting of the National Federation of Fruit and Potato Trades' Association in Liverpool on March 20th the President said that, under the spur of motor transport, the railway companies had given them the "early next morning" delivery, the flat rate, and other things which previously the Association had always been told could not be done. They now had their opportunity to secure goods trains run to scheduled times.

The steam rail cars on the London and North-Eastern Railway, which are to be used in an intensive train service on minor lines, are to be named after celebrated stage coaches. The first is named "The Tally-Ho." The interior of each coach is to be decorated by a framed notice giving particulars of the running of the old stage coach after which the steam coach is named, and offering 5s. reward for supplying to any L.N.E.R. stationmaster hitherto unpublished information about the old horse coach of that name.

In its obituary of Sir William Forwood, of Liverpool, *The Times* of March 24th said that Sir William was the first chairman of the Liverpool Overhead Railway—"the first full gauge electrical railway in this country." The latter part of the statement is not correct, as the City and South London—a full gauge railway—was opened on December 18th, 1890, and the Liverpool line on April 7th, 1893. The undisputed honour enjoyed by the latter is that it was the first overhead railway in the world to be electrically operated.

At the recent annual meeting of the Mersey Railway the chairman compared the results of 1927 with those of 1902. The latter year was not chosen because it is a quarter of a century ago, but because it was the last complete year of steam traction. In 1902 the railway carried 6·67 million passengers; in 1927 there were 17·01 millions, and whilst in the former year there was a deficit of £4086 in the revenue, there was a surplus of £84,552 last year. The average rate of progress in the net revenue, excluding the seven years of Government control, has been £4924 a year. The chairman added that it had been authoritatively stated that the company held a world's record for the advantages of electrical working.

A rather novel scheme for extending the platform accommodation for trains has just been put into operation at the Wood Green Station of the Central London Railway. There is at the entrance end of the station a turn-out with a sharp curvature which prevented the extension of the platform for the accommodation of longer trains on the main track. The platform has consequently been extended by a wooden structure which can be revolved about a pivot near the tangent point of the turn out, and is supported by wheels running on sector-shaped rails. This part of the platform can be moved into position to suit either of the running rails by means of a pneumatic cylinder and the operating gear is, of course, interconnected with the signals, so that a train coming up the curve cannot run into the protruding end of the movable platform.

It is with regret that we have to report the death of Mr. R. J. S. Insell, late signal and telegraph engineer to the Great Western Railway Company, which took place at Torquay on Sunday last. Mr. Insell joined the signal department of the Great Western Railway at Reading in 1881, and after becoming chief draughtsman in 1893, assistant signal engineer in 1900, was appointed in 1903 assistant signal and telegraph engineer, which post he held until his appointment as signal and telegraph engineer in 1923, when he succeeded the late Mr. A. T. Blackall. Mr. Insell was one of the foundation members of the Institute of Railway Signal Engineers, and until 1926 occupied the position of treasurer. He was elected Vice-President in 1922 and President in 1923. He was intimately connected with the late Mr. Blackall in many signalling developments of recent years, including the Insell-Ferriera system of route-lever signalling.

The report for the year ended March 31st, 1927, of the Indian Railway Board has just reached us. There was an increase, as compared with the previous year, in the number of passenger journeys, but owing to reduction in the fares the passenger earnings decreased by 3·44 per cent. Goods traffic remained about the same. Maintenance expenditure was higher owing to more extensive repairs to way and works and to rolling stock, but a fall in the price of fuel and economy in fuel consumption just compensated for the increase in maintenance, so that expenditure was reduced by 0·03 per cent. The return for the State-owned railways on the capital invested was 5·05 per cent., or 0·26 per cent. less than in 1925–26. During the year 420·79 miles were opened for traffic, of which 280·92 miles were broad gauge, 128·25 miles were metre gauge, and 11·60 miles were 2ft. 6in. gauge. A total of 2551·44 miles were under construction at the end of the year.

The report of the Canadian Pacific Railway on the result of operations for the year ending December 31st, 1927, shows the lowest net revenue in three years, the figures exhibiting a decline of 5,300,000 dollars, as compared with the previous year. The increase in working expenses more than kept pace with the rise in gross earnings, while fixed charges also increased. The gross earnings from the railway and lake steamers were 201,145,751 dollars, as compared with 198,025,592 dollars, but the working expenses amounted to 161,630,180 dollars, as compared with 153,080,465 dollars, leaving the net earnings at 39,515,571 dollars, as against 44,945,127 dollars. Special items of income, amounting to 11,876,560 dollars, brought the total income to 51,392,131 dollars, while fixed charges of 15,378,867 dollars left a surplus of 36,013,261 dollars, as compared with 41,325,039 dollars. Deductions for the pension fund of 600,000 dollars, for preferred dividends of 4,005,944 dollars, and for ordinary dividends of 26,000,000 dollars, left a surplus for the year of 5,407,320 dollars.

Notes and Memoranda.

According to Mr. P. Z. Caverhill, Chief Forester of British Columbia, the forests of that country can, under conservative exploitation, supply at least five times the present cut without seriously depleting the capital stock. Mr. Caverhill added that, with a stand of 350,000 million feet board measure of timber of commercial size, and with over 100,000 square miles of land on which young forests are established, British Columbia could easily produce from 5000 million to 7000 million board feet per annum, provided that the trees were afforded reasonable protection.

Artificial lightning of 3,600,000 volts, the highest ever obtained and about seventeen times greater than that of any transmission line in America, has been produced in the high-voltage engineering laboratory of the General Electric Company at Pittsfield, Mass. Mr. F. W. Peek, jun., in charge of this work, announced the achievement on March 7th, in speaking before the regional convention of the American Institute of Electrical Engineers in St. Louis. The new generator is unique in operation. The electricity is gradually stored in artificial clouds just as electricity is stored in real thunder clouds, Mr. Peek said, and is then discharged in a blinding flash.

A plant has been put to work at Drumpeller, Alberta, for the low-temperature distillation under vacuum of lignite. According to the *Albertan*, the plant utilises electricity to heat the coal in vacuum. The raw coal enters the retort and passes through ten tables, being heated gradually by electricity to a temperature of 1150 deg. at the bottom table. The coal does not burn, being under vacuum all the time, and after being cooled by water it is brought out at the bottom as char, deprived of all volatile matter. The gases are drawn off by a vacuum pump, cooled and by-products extracted. The capacity of the experimental unit is a carload of char a day, or 35 tons.

It is claimed that the Ontario Hydro-Electric Power Commission is the largest power enterprise operated under public ownership. It has now in use 1,600,000 horse-power, with another 1,000,000 available. The total available undeveloped power in the province is estimated at 5,000,000 horse-power. The number of miles of transmission lines is 7066. In 1927 there were actually constructed 807 miles of rural transmission lines, and the Government contributed 1,100,000 dollars in rural bonuses on this account. The entire debt to the Province at the end of the fiscal year 1927 was 147,485,906 dollars, and the number of homes served from the hydro-electric station was 420,000.

Some reinforced concrete sleepers that have been in the high-speed heavy service main track of the Pennsylvania Railroad for nearly twenty years have been repaired successfully, according to the *Engineering News-Record*, patches of crushed or disintegrated concrete being replaced, so that the repaired sleepers are practically as good as when new. Seven sleepers were thus repaired during 1927 and replaced in track. At the same time new plates were applied to replace those that had buckled under the heavy wheel loads, and new bolts were inserted for the rail clips. In the repair work the broken parts of the concrete were removed and the rough surfaces of these pockets cleaned. New concrete was then rammed into place and trowelled to a smooth surface, and was found to make a satisfactory bond with the old concrete.

It is reported from Warsaw that a commission of engineering specialists has just concluded a series of experiments and tests with a new alcohol composition, invented by an engineer named Jezierski. The commission has reported that when used for motors this composition gives better results than petrol, while at the same time there is an economy in fuel consumption of from 30 to 55 per cent., and that it gives off no smell, ensures even running of the motor, and requires no multiplication of oilings nor alteration of existing mechanism. The invention, it is declared, may mean a revolution in the cost of the use of motors and tractors, and opens up vast prospects for Polish agriculture, while, inasmuch as it is prepared from ordinary spirits and wine, it will be of no less importance from the military point of view, since it will make a country independent of petrol supplies from outside.

One of the most recent official boiler explosion reports deals with an accident to a small locomotive boiler with a steel shell, a copper fire-box, and brass smoke tubes. Fortunately, no one was very seriously hurt by the collapse of one of the tubes. These tubes were nominally 0·116in. thick when new, but that which failed was only from 0·02in. to 0·065in. in thickness. The boiler was, by the way, scarcely over four years old. In his comments, the Engineer Surveyor-in-Chief says: "The brass smoke tubes were immune from corrosion on the water side, but this advantage over iron or steel tubes was counterbalanced by the heavy wastage which occurred at the smoke-box where the tubes were exposed to waste gases and moisture. Defects in tubes may sometimes be difficult to detect, but in this case the bad condition of the tubes was sufficiently indicated before the explosion to those responsible, and they should have been carefully examined. It would then have been evident that renewal was necessary."

Experiments with a new type of high-power short-wave valve recently developed by engineers of the General Electric Company laboratories at Schenectady, N.Y. have produced results of an unusual and decidedly interesting character. Those in control of the experiments report that meters in adjacent rooms have run wild, that delicate measuring instruments have been twisted or broken, that the new apparatus has emitted a warm glow, subjection to which has been followed by increasing pain in limbs and joints, that rats in a cage placed close to the radiating wire have become excessively animated, and then, if exposed too long, have died, that a new incandescent lamp has been lighted to full brilliancy without wires or socket, that a cold copper bar lying on the floor has blistered the hand of a man picking it up, that a neon tube has suddenly flooded the room with its glow when merely touched, that simple food has been cooked in a glass tube suspended from a receiving aerial, and that many less spectacular effects have been experienced.

Miscellanea.

Some shallow carboniferous strata have been discovered in the basin of the Viar, Seville Province of Spain.

The total production of coal on the Newcastle and Maitland fields, New South Wales, has shown a steady annual decrease during the past four years, from 8,077,689 tons in 1924 to 6,800,000 tons in 1927.

It is proposed to construct an aqueduct capable of conveying from 20 million to 30 million gallons of water a day up the Yarra Valley, beyond Warburton, for augmenting the supply of water to Melbourne.

The Gold Medal of the Institution of Mining and Metallurgy has been awarded to the Right Hon. Sir Alfred Mond, "in recognition of his scientific and industrial services in the development of the mineral resources and metallurgical industries of the British Empire." The medal will be presented to Sir Alfred Mond at the annual general meeting of the Institution to be held at Burlington House on Thursday, May 17th next.

New extensive resources of iron ore are being tapped in the Hunsrück, the high ground between the Rhine and Moselle, by the Thyssen and Krupp firms. The former concern had so far advanced its works that by the end of February the daily despatch of ore to the Ruhr had reached 200 tons. The ore is loaded into barges at Bingen. Krupp's borings and works were not quite so far advanced, but eventually their output will be even more than 200 tons a day.

The Provincial Government of British Columbia will take steps this summer to determine definitely the water-power possibilities of the Chilco River country, midway between Vancouver and Prince George, over which a water-power reserve was placed a year ago. The water powers of that locality have been estimated to be capable of development to the extent of 1,000,000 horse-power, and the Government will now send a survey party in to make scientific measurements and determine the exact possibilities.

The Canadian Government is asking Parliament for permission to establish a Canadian Bureau of Standards, with a director and facilities for the testing of electrical equipment and appliances of all kinds. Consent and co-operation of the provinces have already been obtained. Both Canadians and British have urgently applied to the Government for such a bureau. Heretofore, in order to meet fire underwriter requirements, products of this section had to be subject to the approval of the United States Laboratories.

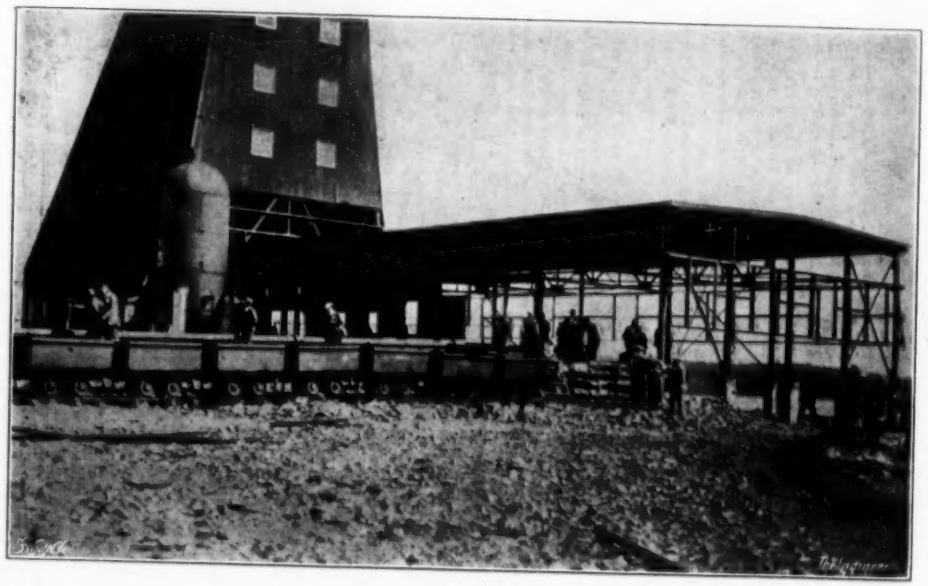
The total number of examinations made of boilers during the year by the Manchester Steam Users Association was 26,768. Of them, 11,421 were those known as "internal," "flue," and "entire." Thus the number of such examinations is practically equal to the number of boilers under the Association's enrolment. Since the publication of its last report the Association has recorded the occurrence, outside its ranks, of seventy-one explosions in the United Kingdom. These resulted in the killing of fourteen persons and injury to forty-eight others. Thirty-two of these explosions, by which seven persons were killed and nine others injured, may be termed "Boiler explosions proper," while the remaining thirty-nine, killing seven persons and injuring thirty-nine others, may be termed "Miscellaneous" explosions, *i.e.*, those arising from steam pipes, stop valves, kiers, drying cylinders, bakers' ovens, &c. During the period named, reports have been received of seventy-one preliminary inquiries held by the Board of Trade under the Boiler Explosions Acts, 1882 and 1890. Of these inquiries two were followed by formal investigations, at one of which costs amounting to £100 were ordered to be paid by the parties found to be in default

Very shortly, one of the most notable hydro-electric power plants on the North American Continent will be brought into operation in British Columbia. This is the Alouette plant of the B.C. Electric Railway Company, which will add 12,500 horse-power to the power system at a cost of 2,500,000 dollars. It will be unique in that no operator will be needed, the single generator being controlled from the Stave Falls Power House 11¼ miles away. The new plant is the second largest automatic power installation on the continent, being exceeded in size only by one station in the State of Washington, U.S.A. Another unique feature is that water, which would ordinarily find its way down the Alouette River to the Fraser River, is being diverted through a tunnel, driven 3400ft. under the mountain range, into Stave Lake. In this way the water will be used for power development at the Alouette plant, again at the Stave Falls plant, and later it will be used a third time, when the B.C. Electric's plant at the first canyon of Stave River is built. The Alouette plant built at the mouth of the tunnel will utilise the head created by the difference in level of 140ft. between Alouette and Stave Lakes. The storage capacity of Alouette Lake has been increased by a dam raising the lake level 45ft.

The Secretary for Mines announces that he has made an Order under Sec. 33 of the Coal Mines Act, 1911, as amended by the Coal Mines General Regulations (Safety Lamps), 1927, approving the "Ringrose (fire-damp alarm) lamp" for use in all mines to which the Act applies, subject to certain conditions set out in the Order. This lamp is, says the *Manchester Guardian*, intended not as a means of lighting, but to give visible warning of the presence of dangerous percentages of fire-damp in air. A current of air passes into the lamp through the protecting gauzes to a combustion chamber consisting of a porous pot containing a heated wire. If and so long as fire-damp is present in the ingoing air it is continuously burned by the hot wire, and a partial vacuum is thus created and maintained inside the porous pot. This vacuum deflects an aneroid diaphragm in such a way that it completes an electric circuit, which lights up a red bulb as warning of the presence of fire-damp in the air. The apparatus is adjusted so that the circuit is not completed and the warning light is not shown until the percentage of fire-damp in the air exceeds a fixed minimum limit—which can, by readjustment by the makers of the lamp, be varied if necessary. The warning light remains on as long as fire-damp in excess of the fixed limit is present in the air.

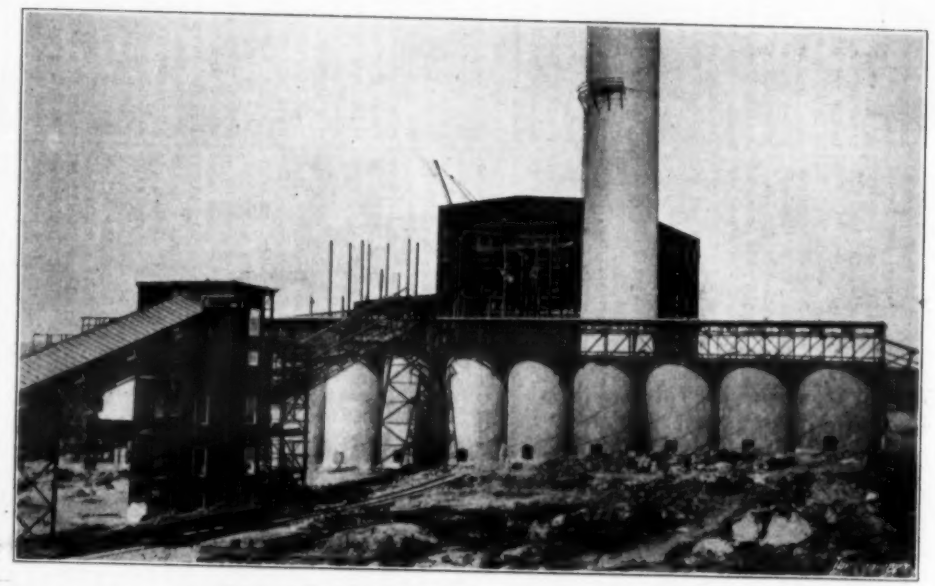
THE HORNE COPPER MINE AND SMELTER AT NORANDA, QUEBEC

(*For description see page* 376)

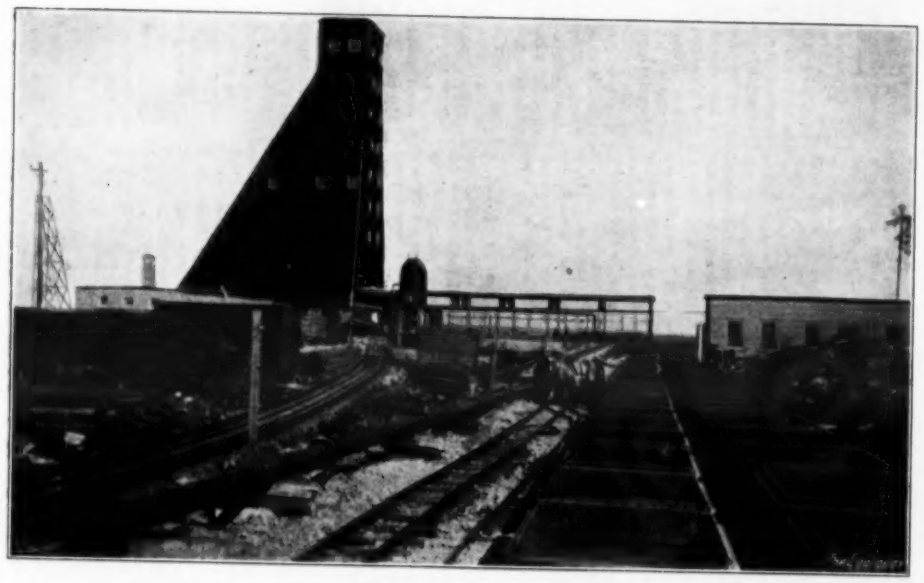


HEAD OF MAIN SHAFT

GENERAL VIEW OF THE MINE



CONCRETE COAL STORAGE BINS AND ROASTER BUILDING



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THE ENGINEER.

APRIL 6, 1928.

Output and Power.

ON Tuesday last the fourth of the valuable memoranda which are being prepared by the Committee on Industry and Trade—the Balfour Committee appointed in 1924—was published. Two more reports are already in the press and with their issue the Committee will complete its long labours with the exception of a concluding volume, in which, it is understood, the whole matter will be summed up and in which recommendations for the improvement of British industries will be advanced. To offer anything approaching an exhaustive review of the present memorandum, which is entitled "Further Factors in Industrial and Commercial Efficiency," is out of the question. The volume runs to nearly 360 pages and covers a vast number of questions; moreover, much of it is outside the direct field of engineering, although it is desirable to remember that to-day there is scarcely an industry in the world that can be conducted without the help of the mechanical engineer. Hence, since engineers depend for their welfare upon the progress of nearly all industries, they have an interest in them which is very little less than direct. Indeed, we might go still further and say that all industries are so closely knit together that it is well nigh impossible to touch one without touching all. Even the making of fake antique furniture, fake old masters, fake Georgian wall papers, which, fortunately, may be regarded as an individualistic occupation, is not without its repercussion on other industries, for it depends upon the transport provided by engineers to convey its products to that continent in which its best market is found. In view of this bond between all industries, we may commend the foresight of the terms of reference to the Committee under which it is covering the whole field of British industries, whilst we find ourselves compelled to consider but a very small portion of its great enterprise.

Regarded from the statistical point of view, it is a sad thing that industrial facts will rarely allow themselves to be arranged neatly and concisely. We may, indeed, take a single factory, sometimes even a whole industry, and collate all the data as formally and concisely as the experimental observations on a turbine or an alternator. But if an attempt be made to handle an industrial or trade problem on the large scale, all sorts of incidental matters interfere and render it impossible to reach a clear-cut conclusion. For example, it has frequently been said that an important factor in the industrial prosperity of America is the high proportion of power per man employed. But to say, on the strength of that observation that other countries have only to increase their power per man to the same level in order to enjoy the same benefits would be quite wrong. A great many other facts have to be considered—the cost of power, the cost of labour, the capital costs of machinery, the incidence of local rates, the temper of Labour, and many other items affect the conclusion. Power can, obviously, always increase the output per man, but it does not follow that, always and invariably, it can do it more cheaply or that it is expedient to employ it. The circumstances which prevail in each country and each industry must be considered; and when they are considered it is found quite impossible to reach a universal law. Even in America the completely automatic factory—a not impossible conception—does not exist; there is always some stage in every process at which, for some reason or another, it is more economical or more expedient to use manual labour than machinery. In the Report which now lies before us there is an analysis of certain parts of the Third Census of Production, that of 1924, in which figures bearing upon this question are given. These figures indicate that, in the industries covered, the power capacity in this country increased between 1907 and 1924 by about 75 per cent., from eight million horse-power to thirteen and three-quarters. As the number of persons had also increased, the net increase of power *capacity* was roundly 50 per cent. per capita. We have italicised the word "capacity." It is important, for it must not be overlooked that a low load factor—using the word in something less than its restricted electrical sense—is one of the obstacles to the wider use of machinery. A machine has to be paid for whether it is working or not, and a few weeks' idleness may more than counterbalance the gains it makes when in full use. That the figures represent capacity, not actual employment of power, must therefore be borne in mind. Now the Committee says, "It is, of course, not to be expected that the productivity of an industry will increase in direct proportion to the increase in mechanical power by which it is assisted" and "it is evident that *per capita* productivity depends on a number of factors of which mechanical power is only one." The first of these two quotations would seem to call for explanation, for if we understand it, it is meant to imply that it is not right to expect that the percentage increase in the rate of output of a factory will be at least equal to the percentage rate in increase of power. Whilst it may be true in some cases that the output is not doubled when the power consumed is doubled, there are at least as many in which the output is far more than doubled. If the number of men employed must be doubled when the power is doubled, then, whilst the output per man remains constant, the *productivity* should increase in direct proportion to the power, but in other cases, where, for example, one man takes charge of an extra machine, doubling the power might very nearly double the output per capita, or if the increase in feed and speed, which is approximately proportional to power, is at the rate of ten per cent., an increase of ten per cent. per capita in the output might reasonably be expected. If it is not attained, it is because the other factors referred to in the second quotation come into play, and, as we have already observed, those other factors may entirely vitiate comparisons between any two nations or even between any two factories. In the United States it appears that between the years 1904 and 1925 the two exactly balanced, the net increase in *per capita* output and the increase in "horse-power per head of employees" being both 64 per cent. But there remains yet another consideration. Every manufacturer has, at some time in his career, found it necessary to consider the adoption of new machinery that would increase his rate of output, but he has not infrequently discovered that although the output was increased, the cost per unit produced was higher. He has then had the troublesome task of deciding whether the increased output would more than balance the augmented cost. In view of the high prices which prevail generally in America, it is not certain that the employment of more mechanical power *per capita* is actually economical in all cases. Unfortunately, this is another of those cases which are so confused by side issues that it is quite impossible to reach

a definite answer. We may, however, remember that America requires and can absorb a vast output, and it is possible that *rate of production* may be, in that country, a factor of far greater importance than in this. In conclusion, therefore, whilst power *per capita* is not a factor which we can afford to neglect, it is not, as some people seem disposed to believe, the prime key to industrial regeneration.

We find that we have been led into the discussion of little more than two or three sentences of the Report. That may not unjustly be regarded as scarcely fair to a publication which from cover to cover is full, not only of statistical data, but of illuminating comments upon them. We may, however, claim that since these few sentences give so much food for thought they do indicate how much more there is to be found in the whole. It is, in fact, a document to which in coming years free reference will be made and—we may add—from which different men will draw different conclusions. One cannot read it without being impressed by the enormous difficulty of analysing scientifically a country's industries. At every turn, just when we seem to have arrived at some definite result, we find that qualifications and conditions, sometimes quite indecisive, have to be taken into consideration, and our well-laid argument crumbles under our hand. Whether Sir Arthur Balfour and his large Committee, with its varied interests, will be able to reach definite conclusions must remain a problem until the final volume appears.

South African Railway Electrification.

Almost every year at least one paper on railway electrification is read before the Institution of Electrical Engineers, but the first member to deal with a long-distance scheme carried out by British engineers is Mr. F. Lydall, who on March 29th presented a paper on the Electrification of the Pietermaritzburg–Glencoe Section of the South African Railways, a scheme which has, no doubt, cost a very large sum of money. It involved the equipment of 170 miles of narrow-gauge railway, mostly single track, running through difficult country, and for dealing with 30,000 tons of goods per day in one direction and a passenger traffic of from 1000 to 1500 tons. On a single line with the characteristics which the paper describes, it is only to be expected that electric locomotives, with a practically unlimited supply of power on which to draw, should lead to considerable improvement in the traffic. Before electrification, the schedule for steam locomotives hauling the heaviest trains between Glencoe and Pietermaritzburg was 16 hours 30 minutes, with loads from Glencoe to Ladysmith of 1000 tons, from Ladysmith to Mooi River loads of 820 tons, and from Mooi River to Pietermaritzburg 850 tons. Three electric units, manipulated by one driver and an assistant now convey 1500-ton trains the whole distance in a period of 10 hours 15 minutes. Under steam conditions the factors that gave rise to slow transit were low speeds on gradients, the remarshalling of trains at Ladysmith, Mooi River, and Pietermaritzburg, and the time occupied in watering and attending to the locomotives during the journey. A 1500-ton train is now conveyed over the entire route between Glencoe and Pietermaritzburg by electric traction without being disturbed. The average speed up the incline between Estcourt and Mooi River, where there is a ruling gradient of 1 in 65, is 21 miles per hour, compared with 8 miles per hour with steam, and the electric locomotives require little or no attention *en route*. The heaviest tonnage moved south of Ladysmith, on any one day before the line was electrified, was 25,351 tons, which could not be maintained for any length of time; but experience shows that there is no reason why, with additional equipment, the existing line should not handle up to 40,000 tons a day or more.

These facts indicate that electrification can do a great deal to increase the capacity of a line of this nature, and that long-distance electric schemes are sometimes justified. A feature of Mr. Lydall's paper is that it deals with some of the troubles that have been encountered, although, according to reports, more might have been said in this connection. Credit must, nevertheless, be given to Mr. Lydall for having said much more about troubles than is customary in technical institution papers, and for having indicated how some of the difficulties were overcome. Lightning seems to have caused a great deal of anxiety. There is probably no part of the world where lightning is so severe as in the north of Natal, and troubles from it were not unexpected; but in order to avoid putting the railway authorities to unnecessary expense, the engineers decided to wait until the line was put into operation before settling the question of what protective gear should be provided. There is little doubt that if the line had been in, say, Switzerland or Sweden, and the work of electrifying it had been undertaken by continental engineers, it would have been operated with 16⅔ single-phase current, notwithstanding the arguments which Mr. Lydall puts forward against it. No one familiar with the ideas of the bulk of British electric traction engineers would expect to find consultants and manufacturers in this country advocating anything but direct current. In the present case, however, it has been necessary to adopt the highest pressure permissible, namely, 3000 volts, and to employ motor generators in the sub-stations. Continental firms have long ceased to take interest in the old controversy concerning the relative merits of alternating and high pressure direct current, because they now make both types of equipment, but that does not alter the fact that some of Mr. Lydall's statements about single-phase operation will not be universally accepted. He states, for instance, that all available estimates at the time the work was begun showed that the cost of maintaining single-phase locomotives was substantially higher than direct-current locomotives. For a very long time past, however, one, at any rate, of the Swiss electrical firms has contended that this is untrue. Properly designed 16⅔-cycle single-phase motors are said to be, practically, as cheap to maintain as direct-current motors. In any case, Mr. Lydall ignores the fact that on the railway under consideration no fewer than twelve sub-stations have to be maintained in good working order, and that these sub-stations must give rise to a considerable loss. One of them contains three machines, seven contain two machines, and four single machines. There are thus twenty-one motor generators in all, each rated at 2000 kilowatts and consisting of a synchronous motor coupled to two 1500-volt generators. If we take the component parts of these motor generators, we find that there are sixty-three machines to be kept in order, as well as all the automatic equipment. Even if 3000-volt rectifiers had been available when the job was started, they could not have been adopted because it was desired to make the motors regenerate, but on other 3000-volt direct-current railways, they might show distinct advantages. Although Mr. Lydall states that at the time the work was begun no completely satisfactory single-phase regenerative scheme was available, regenerative single-phase railways have been in successful operation on the Gothard Railway and on the Norwegian Ofoten Railway, Riksgraensen-Narvik, for a considerable time. The author's strongest argument against the use of single-phase traction is that the current needed cannot be used for general industrial purposes. Frequency changers are therefore necessary for the railway supply, but some continental engineers contend that even then the high pressure that can be applied to the overhead line makes the single-phase system desirable. Fewer sub-stations are needed and high-voltage commutator machines are eliminated, both in the sub-stations and on the trains. Difficulties were apparently contemplated in building single-phase locomotives of the requisite power for the 3ft. 6in. gauge. Single-phase locomotives would, it was thought, be unduly complicated and costly, as compared with direct-current engines. We cannot imagine, however, that the direct-current locomotives in use were particularly cheap, and judging from the example exhibited at Wembley they are not altogether simple. Three locomotive units are employed to haul the heavy trains. Each contains two motor generators, and, owing to the fact that the pressure cannot be transformed down, all the gear has to be designed to withstand the full pressure to earth. But it is obviously absurd to discuss the cost of any one particular part of the scheme. The main point is, What has the whole job cost? On this question the paper throws no light whatever.

Needless to say that, as the paper was read befoer the Institution of Electrical Engineers, it was well received. Mr. Roger Smith and other gentlemen who have no sympathy with anything but direct current, thought that the whole scheme was admirable, and one speaker went so far as to say that there was every prospect of this 3000-volt system being made the standard system for all long-distance railways. Possibly at the time the scheme was started the engineers who were responsible for the design were justified in specifying this particular form of equipment, but we should be sorry to think that there is anyone who believes that a cheaper and better system of main line electrification cannot be devised. Mr. W. M. Mordey was bold enough to suggest that although alternating current was considered unsuitable at the time the contracts for the scheme were let, it was just possible that it might be employed to-day. Although he did not contend that the consulting engineers had made a mistake, he appeared, like ourselves, to feel that something more simple and less costly was needed. In the year 1891 Mr. Ward Leonard patented a system, which, in a modified form, would seem to meet the requirements of long-distance electrification. Subsequently, a similar proposal was put forward by Messrs. Mordey and Jenkins, in a paper read before the Institution of Civil Engineers. Briefly, it was proposed to convert high-pressure alternating current collected from a single overhead wire into direct current by means of a motor generator on the locomotive, as is now being done on some of the large electric locomotives in America. We do not suggest that this scheme could have been adopted on the Pietermaritzburg–Glencoe section of the South African Railways, notwithstanding that the locomotive units are already equipped with two motor generators; but we do consider that if the same ingenuity that has been displayed in the design of automatic sub-stations, high-speed circuit breakers, &c., had been devoted to the problem of utilising 50-cycle current on the overhead wire, long-distance schemes in general would have been made more attractive. A German firm claims to have built a successful 50-cycle single-phase locomotive with 50-cycle motors; Hungarian engineers propose to collect 50-cycle single-phase current and convert it into three-phase current; whilst the idea of collecting 50-cycle single-phase current and rectifying it on the locomotives is not, in our opinion, beyond the range of possibility.

The Collapse of the St. Francis Dam.

At midnight on March 12th the St. Francis Dam, which formed part of the water supply system of Los Angeles, suddenly failed, with the result that vast volumes of water rushed down the canyon across which the dam had been built, doing an enormous amount of damage and causing the death or disappearance of hundreds of persons. With great courtesy our contemporary, *Engineering News-Record*, has sent us advance copies of the pages in its issue of March 22nd, which contain an account written by Mr. Nathan A. Bowers, the Pacific Coast Editor of that journal, who hurried to the spot from San Francisco as soon as the disaster was reported. Writing on March 16th, Mr. Bowers reported that the toll of life and property had not then been fully reported, but that a total of 205 bodies had been recovered, while 200 people were still reported missing. In what follows we give a fairly full summary of Mr. Bowers' report, for much of which we have used his own words.

The St. Francis Dam was a concrete structure of the gravity type, arched in plan—see Figs. 1 and 2. It was built across the San Francisquito Canyon, 1½ miles above Power House 2 of the Los Angeles Power Bureau, and roughly 45 miles north of Los Angeles. The full capacity of the reservoir which it formed was 38,000 acre-feet, and the reservoir was nearly full at the time of the break. "Without the slightest warning," says Mr. Bowers, "the great structure suddenly broke up; a single piece remained standing, while the rest slumped to the valley floor or was swept out. Great blocks of the concrete mass, weighing many thousands of tons, were carried half a mile or more down the canyon."

The dam was designed by the Los Angeles Bureau of Waterworks and Supply, of which Mr. Mulholland is chief engineer, and was built by that Bureau by day labour. It was, according to Mr. Bowers, planned and built without check or supervision by the State. The California law of 1917, which requires that plans for all dams shall be approved by the State Engineer, exempts those built by the California Debris Commission, by municipal corporations which have a department of engineering, and by water systems under the jurisdiction of the State Railroad Commission.

Ten or eleven miles below the site of the dam the San Francisquito Canyon empties into the Santa Clara River, which flows thence westerly about 50 miles to the ocean, passing through Piru, Santa Paula, Saticog, and other smaller cities. The rush of water washed away the power-house, mentioned above, which was of concrete, buried great stretches of the valley under silt, and did extensive damage to bridges, to roads, and to the branch of the Southern

Pacific Railroad which follows the course of the Santa Clara River. The flood reached Santa Paula, which is 46 miles below the dam, three hours after the rupture, and rough estimates based on channel section and assumed velocity indicate that the peak flow exceeded 400,000 if not 500,000 cusecs. By six o'clock in the morning, however, "the flow had subsided to bank storage and return waters."

The San Francisquito Canyon is tortuous and the crest of the flood reached high up its steep slopes wherever its path was diverted. In the tangents it ranged at lesser heights, 75ft. to 100ft., and the rushing water swept the canyon sides clean for miles.

In the design of the dam, though it was curved

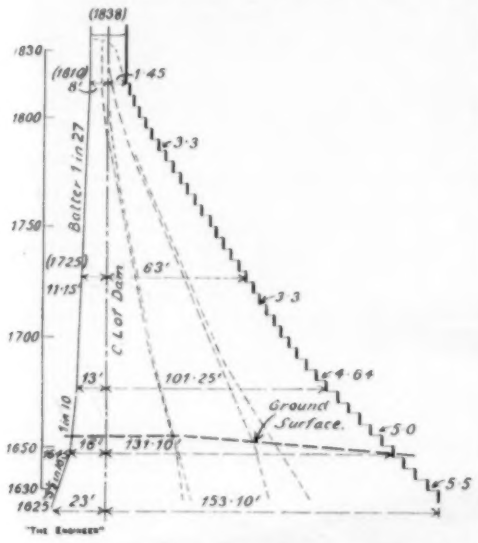


FIG. 1—TYPICAL SECTION OF THE DAM

in plan, no arch action was counted on. The foundation pressure at the toe was limited to 10 tons per square foot, and at the heel to 12 tons. The concrete was taken to weigh 140 lb. per cubic foot; a sample was found to weigh 135 lb. Allowance was made for hydrostatic lift. The dam, at its highest point, was 205ft. high. Its maximum width at the base was 176ft., and the curve of the dam in plan had a radius of 492ft.

The excavation for the foundation was taken down to 30ft. at mid channel in the stream bed, but only to lesser depths on either side. Two kinds of rock, which meet on a well defined plane, now visible on the clean-swept side of the canyon, occur in the foundation. Under the stream bed and on the left bank there is a rock, which is locally known as graywacke shale, but which is rated geologically as a schist. The rock in the right bank above the contact plane is usually referred to as a red conglomerate, and, while some of it is reported not to have been of the best quality, it was nevertheless accepted as suitable for the foundation, and excavations for the base and abutments were made in the rock deep enough to provide what was considered to be a safe anchorage.

No grouting of the rock under the foundations was carried out, but according to Mr. Bowers, it is stated that, in the stream bottom, holes 20ft. to 30ft. deep were sunk at 10ft. or 12ft. centres in the foundation trench, about 15ft. back from the upstream face. Four-inch pipes were brought out of these holes and led through a common drain outlet on the downstream face at stream-bed level. There were:—(*a*) No inspection tunnel; (*b*) no concrete cut-off wall; and (*c*) no reinforcement in the dam. The dam contained no vertical joints, as it is said not to be the policy of the Los Angeles Water Bureau to make provision in design for contraction joints, but rather to allow contraction cracks to occur where they will, and to fill them up as may be necessary. Contraction cracks, we learn, did occur in the St. Francis Dam in approximately radial planes, but they were not, it is stated, of such a nature as to affect the stability of the structure.

The dam had been allowed to impound water last year, but, as far as is known, the reservoir had never been quite full until shortly before the break. Residents in the valley had apparently been nervous as to the condition of the dam and there had been talk locally about "dangerous seepage." That rumour, according to Mr. Bowers, had not been substantiated. Indeed, he states that on the day before the catastrophe Mr. William Mulholland and Mr. H. A. Van Norman, his chief assistant, had visited the dam, and that the latter had informed him—Mr. Bowers—that he had "personally observed the seepage beneath and around the dam at that time and found only a reasonable quantity, which was clear as usual. There were no signs of any sort that would indicate danger to the structure."

No earthquakes, continues Mr. Bowers, were noticed at observatories in Southern California at the time of the break, and the possibility that the failure might have resulted from the work of dynamiters is considered wholly out of the question.

After the catastrophe only a portion of the dam, some 100ft. long in the centre of the structure—the total length of which had originally been 650ft.—was left standing. The portions on each side of it had been entirely demolished. As far as can be told without a survey, this central portion was not moved at all. Evidence that it did not shift is, according to Mr. Bowers, afforded by the fact that at the base of its right—west—side, where the stream is now flowing, there is no sign of crushing such as would be almost certain to appear if so great a weight had moved on rock of the character of that on which the dam was built.

On both sides of the erect portion there are now great gaps, each with a maximum width of about 300ft. Everything has been entirely swept away. There is, however, Mr. Bowers tells us, a remarkable difference between the two gaps. That on the right, or west, bank contains not a vestige of concrete. The mass was broken up into fragments, all of which were carried away far downstream. Pieces, some of them as big as 30ft. by 50ft., and projecting as much as 40ft. above the *débris*, are strewn down the channel below the dam. Not one piece came to rest within the first 1000ft., and some large blocks are more than half a mile from the site of the dam.

The gap on the left, or east, bank is, on the other hand, choked with large fragments of concrete, all of them, except one, being piled actually within the gap. The exception is a large piece 80ft. wide, which is resting against the central portion that remained erect. So far as could be judged the entire dam section on that side was represented by the fragments referred to.

Some of the pieces of the concrete have rock still adhering to their bases, the concrete having been strong and sound enough to shear through the aggregate.

The fact that all the fragments from the right gap were carried far downstrean, while those from the left gap were moved but little, indicates, remarks Mr. Bowers, that the initial failure occurred on the right side of the stream. "Possibly," he continues, "the vibration and shock attending the breaking off of the great pieces on the right-hand end of the dam reacted disastrously on that portion near the left bank. Whatever the initial cause, since both ends carried away while flanked on the one hand by a stable dam section and on the other by their hillside abutments, it seems obvious that they had poorer foundation than the central section, which, after all the disturbance, remains erect without support."

On the right bank, we learn, the rock is now bare from stream bed to crest level. The face of the side of the canyon has been eroded to a depth considerably below the surface on which the concrete was poured. Actually to what depth the erosion has taken place, it is impossible to say without special investigation, but it amounted to at least 15ft., and the bank now slopes downstream as well as towards the valley.

As has already been explained, two distinct geological formations meet in a contact plane on this bank of the canyon—see Fig. 3. Along the line of contact is a band of serpentine of seamy formation, which is so softened by water that, here and there, veins can be picked out with the fingers. Above the contact plane, the formation has the appearance of red conglomerate, but *typical samples submerged in water were found to soften in a short time*; the italics are those of our contemporary, which continues:—"Evidently the foundation is not now as firm as it was before saturation, when the concrete was poured."

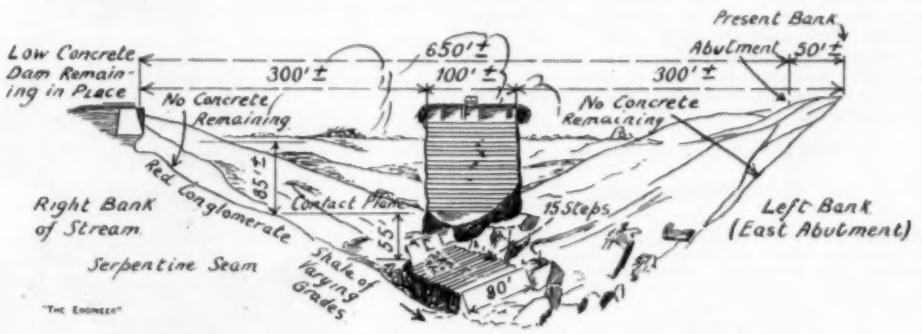


FIG. 3—SKETCH SHOWING CONDITION OF DAM SITE AFTER THE FAILURE

On the left bank the abutment, against which concrete was poured, also appeared to have been cut away by the flood, but as earth slides had covered the slope, the face of the rock could not be examined.

Our contemporary publishes reproductions of a most informative series of photographs taken of different portions of the site. In one of them, which is a view of the base of the right—west—face of the erect central section of the dam, the rock is seen adhering to, and hanging from, the underside of the concrete dam body, which, itself, still remains in its original position. Regarding this view, Mr. Bowers remarks: ". . . The foundation on which concrete was poured has been undermined for a depth of 15ft. or more below the bottom of the excavation. . . ."

Commenting on the disaster as a whole, Mr. Bowers says: "Just where the failure began and what was the sequence of the break up will probably never be known positively. The several investigations now under way may bring to light further data that will alter the aspect of the situation, but the consensus of opinion (March 16th) among engineers who had examined the break was that foundation conditions were at least an important factor, if not the sole cause of the break. The question of how far grouting would have prevented water from getting into the foundations, and how much of a factor this would have been in preventing the break is also being discussed."

As will be readily understood, the failure of the dam affected the water supply of Los Angeles. The dam was built for storing aqueduct water which had already passed through a hydro-electric station, known as Power House 1, but which it was not desired to pass through Power House 2. When the aqueduct was first put into service, the water from Power House 1 was allowed to flow down the natural channel of the river, to be picked up and directed into the aqueduct at an intake below. When the second electric station was built a tunnel was driven from just below Power House 1 to a forebay above Power House 2, and there was therefore provided a second route by which the water might find its way to the aqueduct intake, which was then incorporated in the lower power house. The dam was built purely to conserve aqueduct flow, and except during times of flood, the flow released from the dam into the river channel, and not diverted into the aqueduct, was, by agreement with water users downstream, kept equal to the run-off from the drainage area into the reservoir.

The aqueduct tunnel immediately below Power House 2 is 3 miles long, and it discharges into what is known as Dry Canyon Reservoir. At the time of the disaster, the intake at Power House 2 was open, and the full head of the flood—which amounted to about 100ft. above the intake level—took effect on the tunnel. As a result, three breaks, which totalled 412ft. in length, occurred at points where the conduit changes from tunnel to aqueduct. Because of the destruction of the roads in the canyon it was impossible to send men and materials along them for carrying out the necessary repairs. Hence, it was decided to draw off the water from Dry Canyon Reservoir below outlet level, so as to provide access to the breaks through the tunnel. The section of the

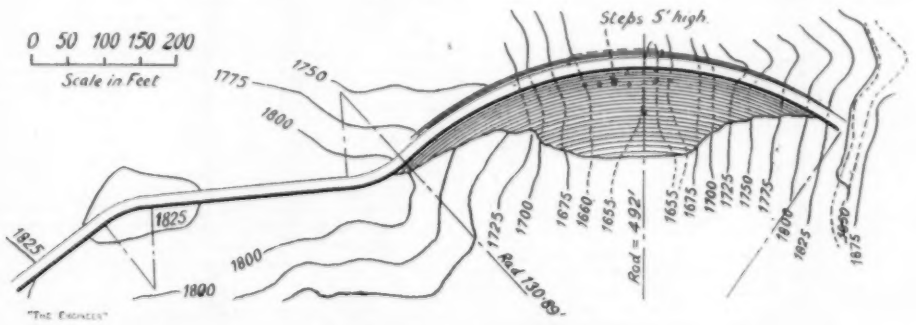


FIG. 2—PLAN OF THE ST. FRANCIS DAM

latter is, it is explained, such as to permit of a flow of 1000 cusecs with a fall of 1½ per 1000. The uppermost break was 2½ miles above the outlet. It was estimated that the repairs would take less than a week to effect; in the meantime the city of Los Angeles drew upon the large storage reservoirs at the lower end of the aqueduct.

As was to be expected, there has been an immediate demand for an inquiry into the causes of this most lamentable disaster. The Los Angeles City Council invited Mr. Elwood Mead, the United States Commissioner of Reclamation, to act as Chairman of an investigating board to be composed of engineers nominated by the American Society of Civil Engineers. The Board of Supervisors of Ventura County, through which the flood passed, appointed an investigating committee, and the Governor of California appointed Messrs. F. H. Fowler and F. E. Bonner as an investigating Board.

Mr. R. F. Goudey, the district engineer of the State Board of Health, was quickly put in charge of sanitation measures in the flood stricken area, particularly with regard to temporary measures in connection with the treatment of sewage in those places where the sewage disposal systems were injured. Effective work was, we learn, done in the flood-stricken area by the Red Cross, and aid from all sides, fortunately favoured by good weather and uninterrupted communications, greatly expedited rescue and repair work.

SIXTY YEARS AGO.

Although the vast majority of files are nowadays cut by machinery, hand-cut files are still in demand for some purposes. The art of their production is by no means lost. It is still carried on with all the skill and dexterity which characterised it in the days before machinery was introduced. File cutting would appear to be an operation essentially suited to the employment of machinery. Nevertheless, in those days, sixty years or so ago, when the hammer, chisel and file played a much larger part than they do to-day in the routine of an engineering establishment, hand cutting had no rival. In our issue of April 3rd, 1868, a correspondent signing himself "A Mechanic" commented upon "the very strange circumstance" that file cutting by machinery was not yet a settled practice. The operation, he claimed, was one of the simplest that could be done by machinery. Why was it not the custom to employ machinery for the purpose? He suggested two reasons. His first was that the Sheffield masters dared not introduce file-cutting machines into their workshops, a reference presumably to the strained situation, culminating in some notorious outrages which then marked the industrial life of the city. His second reason was that two companies, the Lancashire Steel Company and the Birmingham File Company, had failed to make a success of machine cutting, and that their failure was acting as a deterrent to others. In reality, he said, the misfortunes of these two companies arose from their own fault. Both had been formed for the production of large quantities of files before the machines had been properly tried. The Lancashire Company had spent £22,000 on land, buildings and machinery, and the Birmingham Company £80,000. The first had installed twenty-five machines and the second fifty. A machine capable of cutting fifty dozen 14in. hand bastard files per week of sixty hours could, our correspondent held, be made for £100. He therefore argued that a capital of £10,000 ought to have been enough for the Lancashire Company and £20,000 for the Birmingham Company, and that if they had only been content to creep, walk and then run the result would have been very different. That there was ample opportunity for making a commercial success of machine cutting was shown by the fact that the current Sheffield list price for cutting the 14in. files referred to above was 4s. per dozen, whereas the cost of the work when performed by a machine was not more than 8d. per dozen. The cutting of files by machine had proved so far unprofitable, he concluded, because too much capital had been expended for the work to be produced at a profit.

BOOKS RECEIVED.

Science for You. By J. G. Crowther. London: George Routledge and Sons, Ltd., 68, Carter-lane, E.C. 4. Price 5s. net.

Coloured Thinking. By Dr. F. Fraser-Harris. London: George Routledge and Sons, Ltd., 68, Carter-lane, E.C. 4. Price 5s. net.

Properties of Steam and other Vapours. Compiled by J. B. Peace, M.A. Cambridge: Deighton, Bell and Co., Ltd. Price 1s. net.

Jahrbuch der Schiffbautechnischen Gesellschaft, 1928. Berlin: Schiffbautechnischen Gesellschaft, Schumannstrasse 2.

Directory of Papermakers in Great Britain and Ireland, 1928. London: *The Paper Makers Monthly Journal*, 47, St. Mary Axe, E.C. 3. Price 5s. 6d.

An Introduction to the Metallurgy of Iron and Steel. By H. M. Boylston. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 25s. net.

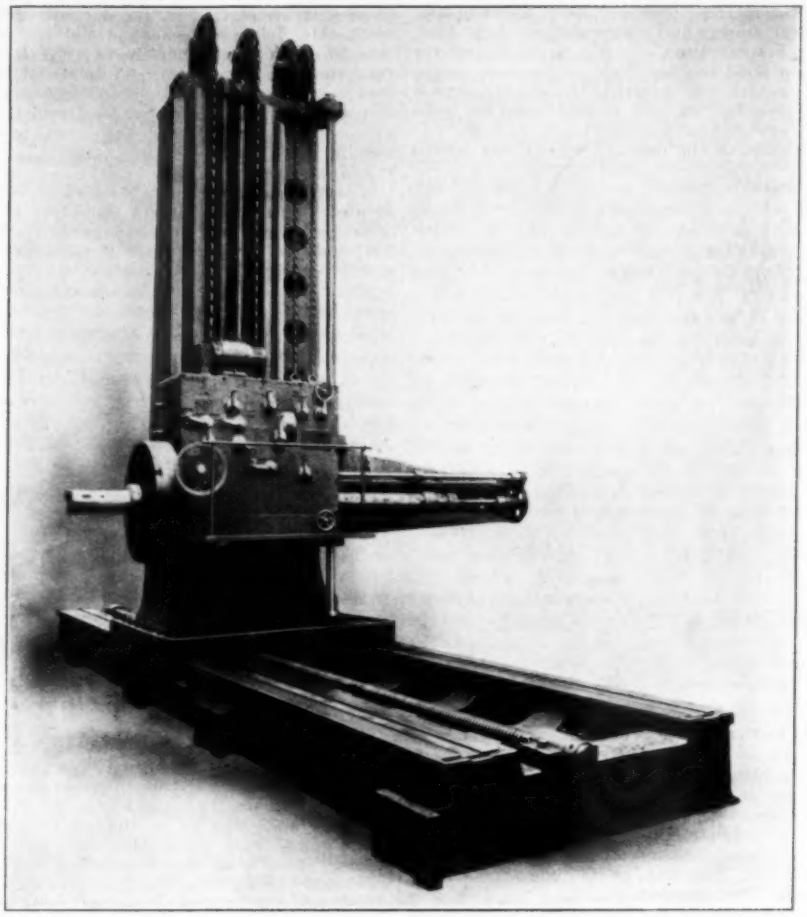
The Sydney Harbour Trust Commissioners: Twenty-seventh Report, being for the Year ended June 30th, 1927. Sydney: Alfred James Kent. 1927. Price 1s. 9d.

Chemical Engineering and Chemical Catalogue. Fourth edition. Edited by D. M. Newitt. London: Leonard Hill, Ltd., 173, Fleet-street, E.C. 4. Price 10s. 6d. net.

Annali dei Lavori Pubblici (già Giornale del Genio Civile): Ministero dei Lavori Pubblici, Consiglio Superiore: Dicembre, 1927. No. VI. Rome: Provveditorato Generale dello Stato, Libreria. 1927.

DRILLING, BORING AND MILLING MACHINE

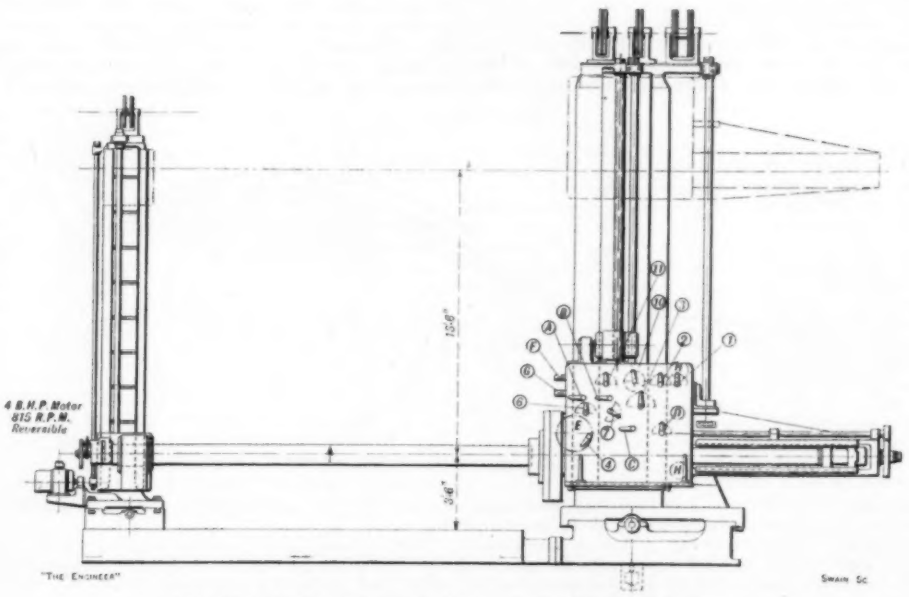
HULSE AND CO., LTD., MANCHESTER, ENGINEERS



A Large Horizontal Drilling, Boring and Milling Machine.

The large universal drilling, boring and milling machine illustrated herewith, has recently been built by Hulse and Co., Ltd., Manchester. The machine consists of a bed upon which the column slides, whilst the spindle slide moves in turn vertically on the column, both motions being derived from a rotating nut on a fixed screw, the thrust of which is taken on ball bearings. The main driving motor is mounted on the base of the column with which it is traversed along the bed. The spindle slide, which is balanced by two separate counterweights sliding in guides within the column, has long bearings upon the upright face. The sliding ways for the spindle on the column and for the column on the bed are each designed on the narrow guide principle and are fitted with square gibs and taper strips for taking up wear.

The spindle of high carbon forged steel is rotated by a long tube running in gun-metal conical bearings, a large internally-geared face plate being mounted on the front end of the tube. The rear end of the spindle is carried by a bracket which is fitted with a heavy ball thrust washer for taking the end thrust on the spindle, and moves within guides in a well supported slide. Special means are provided for gripping the spindle within the tube when milling with the spindle extended. Other features of the machine are the concentric screw feed to the spindle, whereby any tendency to binding is eliminated, and the independence of the milling feeds from the spindle speeds, the milling feeds being driven by a separate 10 brake horse-power motor mounted on the spindle slide. This motor is of the constant speed reversible type. It will be observed from the line drawing below that all motions are easily controlled by the operator from the platform attached to the spindle slide. The horizontal or vertical quick power traverse motions in either direction to the column along the bed, and to the spindle slide on the column are driven from the 10 H.P. motor just mentioned, electrical safety stops preventing overrunning when traversing.



Machine Arranged with Cross Bed and Boring Bar

The arrangement of the control levers can be followed on the line drawing. The machine is driven by a constant speed motor of 35 brake horse-power, but it can also be arranged to be driven by a variable speed motor, in which case the two levers 1 and 2 are eliminated, the speed control being obtained through the shunt regulator in the usual way. The levers 1 and 2 and 3 and 4 control the sixteen changes of main spindle speeds, while the levers 6 and 7

control the six changes of drilling and boring feeds. Levers 10 and 11 control the six changes of milling feeds. As previously mentioned, the milling feeds and quick power traverse to the spindle slide and column are driven by the 10 horse-power reversing motor, and the lever A puts into gear either the power traverse or milling feeds. The lever B gives the choice of either horizontal or vertical movements of the spindle. The drilling and boring feeds to the spindle itself and the quick power traverse in and out to the spindle are actuated from the spindle. The lever C puts into gear either the boring and drilling feeds or quick power traverse, and the lever D reverses the direction of this feed or power traverse. Hand adjustment of the spindle is provided by a hand wheel E, while the hand adjustment to the spindle slide vertically and to the column along the bed is effected by a ratchet lever mounted on shafts F and G respectively. The position of these is such that the spindle can be adjusted from the front end of the platform overlooking the work plate. The hand wheels H actuate worms and wheels and lock the spindle slide to the column.

Speed changes are effected by means of sliding gears, and the feed changes by means of both sliding wheels and clutches, while interlocking arrangements are provided to prevent any two sets of speed or feed gears being engaged simultaneously.

The adjustable boring bar stay has a counterbalanced capped bearing for a boring bar 16in. diameter. The maximum vertical traverse is 13ft. 6in., and the horizontal traverse on a cross bed is 30ft. Quick power traverse in either direction to the stay along the cross bed and to the bearing for the boring bar vertically is provided, and is actuated from a 4 brake horse-power reversing motor mounted on the base of the stay, the same motor also affording the means of quickly traversing the boring head along the self-acting boring bar in either direction. All the quick running shafts in the machine are fitted with ball journal bearings.

The following are the leading particulars of this machine :—

Diameter of spindle	10in.
Horizontal traverse of column on bed	30ft.
Vertical traverse of spindle slide on column	13ft. 6in.
Feed traverse of spindle	6ft.
Range of spindle speeds	·8 to 80 r.p.m.
Range of drilling and boring feeds	4 to 132 cuts per inch reversible.
Range of milling feeds	1in. to 6in. per min., reversible.
Weight, approximate (machine)	67 tons.
Weight, approximate (stay)	13 tons.

A Note on Experimental Diesel Engines.*

By ENGINEER-CAPTAIN A. TURNER, R.N.

SOME of the earlier experimental work carried out by the Admiralty Engineering Laboratory at West Drayton† has been described in papers read before this Institution, and the present note has been written with the object of discussing some of the more recent developments that have taken place at that establishment.

One of the principal aims of the Laboratory has been to assist, by obtaining experimental data, in the development of reliable and durable Diesel oil engines of high powers on the basis of a minimum expenditure of weight and space which is consistent with a speed or revolution suitable for use with the marine propeller.

Steady progress has been made and knowledge has accumulated during the period of the laboratory's existence, and it is proposed to compress into this paper a few of the lessons learned in following the various paths of exploration. These, speaking broadly, are five in number, those being investigated elsewhere by private enterprise being borne in mind in order to avoid overlapping.

The study centres round the general behaviour and characteristics of engines of the following types :—Four-stroke cycle trunk piston engine ; four-stroke cycle double-acting engine ; two-stroke cycle stepped piston engine ; two-stroke cycle opposed-piston engine ; two-stroke cycle double-acting engine. In each case single-cylinder units have been constructed, and, as a general rule, only the cylinder conditions would be repeated if multi-cylinder engines were constructed from them.

Among others used for occasional studies, the principal engines are as follows :—

(1) *The Digit Engine.*—This engine was built at Chatham Dockyard from designs prepared at the laboratory—at that time at South Kensington. It is of the simple four-stroke cycle type, with a trunk piston having a cylinder diameter of 20in., a stroke of 20in., a speed of 390 revolutions per minute. Its normal B.H.P. is regarded as 300 gross, *i.e.*, without its air compressor, and under these conditions it is used for trials of 200 hours' or so duration whenever required.

It has been used for testing improvements in detail, such as pistons, cylinder covers, exhaust valves, valve gear details generally ; and, furthermore, has been subjected to most severe tests of an exploratory nature, with the object of obtaining more power from a cylinder of this size.

(2) *The White Engine.*—This engine was built by Messrs. J. S. White at Cowes to designs prepared by the laboratory. It is a two-stroke engine—single-cylinder engine of 18in. diameter, 20in. stroke, designed to run at 400 revolutions per minute. The scavenge air was supplied by a stepped piston, and the supercharge air from a crank-driven pump. The scavenging arrangements proved to be generally unsatisfactory, 100 lb. mean indicated pressure at 300 revolutions per minte was not exceeded satisfactorily, and drastic alterations were necessary.

Subsequently, a double-acting engine had commenced its trials and work on the White engine ceased when the new engine became available for experiments with scavenging and other two-stroke features, its principal parts being embodied to form a new trial engine.

(3) *The Doxford Engine* was built by W. Doxford and Sons, Ltd., of Sunderland. It is an opposed piston engine of two-stroke type, having a cylinder 14⅝in. diameter, a stroke of 28½in., and a speed of 360 revolutions per minute. It has given satisfactory service, having in mind the high designed revolutions, and has been used for supplementing the supply of electrical power to the establishment and for testing the durability of cylinder liners and pistons.

(4) *The Datic Engine.*—This engine was designed by the laboratory and its manufacture was commenced by Chatham Dockyard, but on account of pressure of other work caused by an unforeseen change in the general scheme of developments, it was transferred to and completed at the North British Diesel Engine Works, Ltd., Glasgow.

This engine is a two-stroke double-acting engine of high-speed type, having a working cylinder of 25in. bore, a stroke of 22in., with a normal speed of 320 revolutions per minute. The scavenge and supercharge air is provided by pumps driven by two of the three throws in the crank shaft, which are provided for the purpose of balancing the masses of the power line which is over the centre crank. The extension of the crank shaft is used for driving an air compressor. The designed I.H.P. of this cylinder was 2000, and this was obtained after extensive experimental work, with the accompaniment of an invisible exhaust. During the series of trials, the engine was forced up to its limit, and a maximum power of 2300 I.H.P. was attained, the exhaust being almost invisible.

(5) *The Cygnet Engine.*—This is a four-stroke double-acting engine having a single cylinder of 18in. diameter, a stroke of 20in., and a designed speed of 400 revolutions per minute. It was built for the purpose of exploring the possibility of obtaining good results in combustion chambers of generally cramped form, coupled with the advantage of positive scavenging. The engine is at present running preliminary trials with satisfactory results, the exhaust from the underside of the piston not being absolutely clear yet.

It will be gathered, therefore, that from the cylinder considerations power can be obtained more easily from an engine by supercharging through the induction pipe than by supplementing the quantity of the air blast. It must be remembered, however, that the quantity of air utilised in these cylinders is considerable, and unless the air blower or pump revolves at very high speeds, it becomes bulky. The space available may even then be utilised more efficiently by adding another cylinder to the engine—a matter that can only be decided upon for each individual case dependent on which of the three—length, head room, or weight—can be sacrificed most conveniently.

A third method of increasing the power of the cylinder is to work it on the two-stroke principle, and Table II. shows the best results obtained so far in the Datic engine.

It will be noted that at 320 revolutions per minute this engine developed mean indicated pressures of 128 lb. on the top of the piston and 122 lb. per square inch on the bottom, the total I.H.P. being 2083, the corresponding brake mean pressures being 65 lb. and 63 lb. per square inch respectively. The exhaust temperature is lower than in the other cases mentioned, being about 950 deg. Fah.

Another method is to double act the four-stroke engines, and preliminary figures show that it is probable that brake mean pressures of the order of 85 lb. per square inch on the top and bottom of the piston will be exceeded—these having been obtained on preliminary trials.

An approximate comparison may therefore be made between the net brake mean pressures actually obtained experimentally with invisible exhaust, omitting all corrections, some of which may be debatable, for the rather clumsy arrangements necessarily involved in the construction of single-cylinder engines when they have to run at high speeds.

Allowing, say, 10 per cent. for the area of the piston-rod, when compared with the area of the cylinder bore in the case of double-acting engines, the comparison is roughly as given in the table below :—

	Four-stroke single acting.		Four-stroke double-acting.	Two-stroke opposed piston type.	Two-stroke double-acting.
	Naturally aspirated.	Super-charged with equivalent of blower driven off the engine.	Naturally aspirated.	Three cranks supercharged.	One crank supercharged.
Referred brake mean pressures, lb./sq. in.	100	115	81·2	87	61·4
Relative number of impulses	1	1	2	2	4
Speed of revolution	390	390	400	324	320
Comparative B.H.P. per given size of cylinder	1	1·15	1·66	2·89	2·00

Now these experimental engines must be regarded as mere weapons or tools utilised to ascertain as far as possible what can or cannot be done to meet requirements.

In general, the difficulties so far encountered in this form of research may be divided into three main groups, viz., those due to faulty combustion, those due to thermo-mechanical effects, and those due to ordinary mechanical wear and tear ; and it may be advisable to touch upon them as they influence the designer in his attempts to obtain more power, and still more power, from internal combustion engines.

In the Digit engine, efforts to increase its power have been made in two directions, viz., by increasing the supply of blast air and by ordinary supercharging.

By forcing the engine with blast air, the highest indicated horse-power obtained was 500 I.H.P., the mean results over a two hours' test being as shown in Table I.:—

TABLE I.—*Digit Engine : Two Hours' Test at 390 B.H.P.*

R.p.m.	392·7
I.H.P.	497
B.H.P.	390
Mechanical efficiency	78·6 per cent.
M.I.P.	159·6 lb./sq. in.
Blast air pressure	1150 lb./sq. in.
Blast air consumption	80 cub. ft./min.
Compressor B.H.P.	48
Net B.H.P. of installation	342
Net mechanical efficiency	69 per cent.
Fuel	Texas
Lb./I.H.P./hr.	0·336
Lb./B.H.P./engine/hr.	0·428
Lb./B.H.P. (net)/hr.	0·488
Compression pressure	460 lb./sq. in.
Maximum cylinder pressure	630 lb./sq. in.
Injection nozzle	Six 0·130in. holes, 120° angle
Needle valve lift	0·114in.
Exhaust colour	Shaded
Exhaust temperature	1050° F. estimated
Brake mean pressure	110 lb./sq. in.

The brake mean pressure was about 110 lb. per square inch, the mechanical efficiency of the installation, which included separately driven air compressors, large fly-wheel, &c., being low. As will be seen, subsequently, these figures were repeated a year or so later.

The highest power obtainable with invisible exhaust was lower, being about 450 I.H.P., with a mean indicated pressure of 144 lb. per square inch, the corresponding brake mean pressure being 100 lb. per square inch.

Supercharging experiments were carried out with extemporised and unavoidably inefficient apparatus, and mean indicated pressures of 185 lb. per square inch were obtained, the corresponding overall net brake mean pressures being 115 lb. per square inch. The exhaust was invisible—its temperature 1065 deg. Fah. Mean indicated pressures exceeding 200 lb. per square inch have been obtained, the exhaust being all but invisible.

Two series of trials were arranged—first, by running the engine at four different powers and supercharging by degrees—the exhaust temperature being kept as constant as possible, and, secondly, by obtaining the utmost from the engine with invisible exhaust.

It may be taken from general considerations based on the laboratory experience that a brake mean pressure of 125 lb. per square inch can be obtained in cylinders of this size when running under the same conditions with suitably designed apparatus.

A study of the trial results will show that these figures will be altered materially in the event of the compressors and blowers being separately driven.

Experimental results show, therefore, that the opposed-piston type of engine develops the most power for a cylinder of given diameter and stroke, and the question at once arises, "Can such cylinders be accommodated in the space available ?" This is a matter of design involving considerations of space, weight, types of air blowers and auxiliary engines necessary to drive them, which is outside the province of this note ; but it cannot be too strongly emphasised that it is not a matter of mere power per cylinder that eventually counts, but the general requirements of the engine taken as a whole in regard to accommodation on board ship, and these vary considerably.

The speed of revolution of the engine shafting is governed to a large extent by that at which the propellers can be driven efficiently. At 390 r.p.m. the opening and closing of the valves of the Digit engine is undoubtedly noisy, but the limits of speed to which engines of this size may be driven is largely governed by the stresses obtaining in the valve springs, which increase rapidly as the diameters of the valves and the speeds of the cam shafts increase. For similar valves and spring arrangements the working stresses in the spring steel may be regarded as varying with the square of the valve diameter and the square of the cam shaft speed, and possibly this may be taken as a rough criterion of measure of the shock on the valves, cams, cam shaft driving gear, &c. Experience with valve springs in engines with cylinders about the size of the Digit engine shows that it is desirable to consider at least two air valves and two exhaust valves per cylinder head, and tests on another engine with valves on these lines show that the valves are uncommonly silent. The cylinder heads of the aircraft engines are most attractive in this respect, but similar cylinder heads in Diesel engines have been found most awkward to arrange for at present, on account of the difficulties in efficiently water cooling both the cylinder head and the removable valve cages, and also in arranging a practicable reversing arrangement.

In two-stroke engines the cam shaft must rotate at the same speed as the crank shaft, and it is evident that, apart from any consideration of severe working conditions as regards heat the valve springs, if scavenge valves are provided, must be carefully considered, as other things being equal the stresses in the springs may be four times that obtaining in valves of similar size in the four-stroke engine.

It may be observed that, contrary to supposition, the provision of four valves in lieu of two would actually appear to simplify the design of the cylinder head and render it free from casting difficulties, and reduce the risk of cracking between the fuel and exhaust valve orifices. No difficulty has, however, been experienced with this type of cracking at the laboratory, although tested under working conditions corresponding to 203 lb. per square inch mean indicated pressure with cylinder relief valves occasionally lifting at about 750 lb. per square inch.

Attention may be called to the nature of the wear that can take place in cam shaft driving gear, also how inefficient this type of driving gear may become with its narrow limits of pressure intensity and rubbing velocity, either collectively or individually, under which it will work without chattering or even firing up.

At high speeds it follows, therefore, that the mechanical

* Institution of Naval Architects, March 29th, 1928. Abridged.

† For an illustrated description of this laboratory and its engines, see THE ENGINEER, May 4th, 1923.

efficiency of the engine must be adversely affected by gears of this description. Valve gears driven by straight chains of simple spur wheels with ground teeth have been used for a large experimental engine employing wheels up to 3ft. diameter running at speeds from 400 to 200 r.p.m., and have worked smoothly, silently and evidently with a high mechanical efficiency, although the latter has not been definitely measured at the laboratory.

The loading on the teeth of spiral gears, coupled with high rubbing speeds, is incalculable in the event of a valve sticking or seizing, and further difficulties have been experienced with valve-operating gear on account of a desire for compactness having involved occasionally too great an angle of obliquity of links and rods during reversing processes—the forces required to replace rollers on their cams against the heavy spring loading on the valves being considerable. Any error in this direction may lead to

There is another aspect, however, to the question of speeding up such engines or increasing their size, or both, and that is the natural falling off in efficiency—apart from mechanical efficiency pure and simple—due to the general effect of size and speed. The general characteristics of the efficiency curve of these reciprocating engines would appear to be of the nature of that depicted in Fig. 1, as the power required to drive the blowers must increase at an appreciably greater rate than that developed in the main cylinder as the sizes and speeds of revolution increase. It may be unwise, therefore, to assume that because certain high overall efficiencies can be obtained in small engines that they can necessarily be obtained in large ones, and any comparison between large engines of slow speed, or high speed and small engines with high or slow speed, should be made with the greatest care in this respect.

Experiments appear to bear this out, and Fig. 2 shows

Table II.—*Datic Engine: Trials at 120 lb./sq. in. M.I.P. (approx.).*

R.p.m.	251·3	275·5	302·5	316·2
M.I.P., top, lb./sq. in.	124·3	116·3	120·2	127·2
M.I.P., bottom, lb./sq. in.	120·1	114·3	120·2	122·7
I.H.P., top	850	870	994	1097
I.H.P., bottom	743	772	899	955
I.H.P., total	1,593	1,642	1,893	2,052
B.H.P.	904·7	901·5	937·7	988
Mechanical efficiency, %	56·8	54·8	49·6	48
Fuel consumption—				
Lb./hour	556·5	580·5	620	734
Lb./I.H.P./hour, top	0·342	0·347	0·323	0·352
Lb./I.H.P./hour, bottom	0·358	0·363	0·333	0·385
Lb./I.H.P./hour, total	0·350	0·353	0·327	0·367
Lb./B.H.P./hour	0·618	0·644	0·662	0·763
Exhaust colour	C/S8	C/S8	C–C/S8	S–D
Exhaust temperature, °F.	815	805	850	935
Compression pressure, top, lb./sq. in.	585	595	600	610
Compression pressure, bottom, lb./sq. in.	485	515	560	590
Maximum pressure, top, lb./sq. in.	625	600	610	612
Maximum pressure, bottom, lb./sq. in.	675	652	690	720
Scavenge air pressure, lb./sq. in.	4	5½	5½	6½
Supercharge air pressure, lb./sq. in.	4	4¾	5¾	6½
Blast air pressure, lb./sq. in.	1,150	1,190	1,265	1,175
Compressor I.H.P., % of engine I.H.P.	11·9	12·9	12·1	—
Scavenge I.H.P., % of engine I.H.P.	3·6	5·2	5·8	—
Supercharge I.H.P., % of engine I.H.P.	2·7	3·8	4·2	—
Friction H.P., % of engine I.H.P.	25·0	23·3	28·3	—
Heat converted to I.H.P., %	40	39·5	42·7	38
Heat converted to B.H.P., %	22·7	21·7	21·2	18·2
Heat to jackets and covers, %	13·7	13·7	13·1	—
Heat to piston cooling oil, %	7·8	7·8	7·6	—
Heat to exhaust, &c., %	38·5	39	36·6	—

Table III.—*Digit Engine: Tests with Invisible Exhaust and 3·93 lb./sq. in. Boost.*

R.p.m.	351	391	391	391	420
Boost pressure, lb./sq. in.	3·93	3·93	3·93	3·93	3·93
Gross B.H.P.	328	388	416	441	473
Net B.H.P.	251	336	332	350	383
M.I.P., lb./sq. in.	149·4	162·3	166·5	183·8	185·8
I.H.P.	416	504	515	570	617
Gross mechanical efficiency, %	79	77	80·7	77·4	76·8
Net mechanical efficiency, %	60·3	60·7	64·5	61·4	62
Fuel consumption—					
Lb./I.H.P. hour	0·287	0·337	0·322	0·314	0·309
Lb./B.H.P. hour (gross)	0·362	0·399	0·399	0·404	0·391
Lb./B.H.P. hour (net)	0·472	0·506	0·500	0·511	0·483
Lb./hour	118·7	154·7	166	178·7	185
Compressor B.H.P.	43	47·5	49	58	56
Blower E.H.P.	34	34·5	35	33	34
Blast air, cub. ft./min.	63	69	69	83	83
Heat in fuel, B.Th.U./min.	100% 36,100	100% 46,900	100% 53,300	100% 54,100	100% 56,100
Heat to I.H.P., B.Th.U./min.	48·8% 17,600	45·5% 21,300	43·4% 21,800	44·8% 24,200	46·7% 26,200
Heat to jackets, B.Th.U./min.	12·1% 4,380	11·6% 5,450	11·7% 5,890	12·7% 6,900	12·1% 6,800
Heat to piston cooling, B.Th.U./min.	2·8% 1,020	2·7% 1,300	2·8% 1,400	2·9% 1,560	2·6% 1,470
Heat to exhaust, B.Th.U./min.	36·3% 13,100	40·2% 18,850	42·1% 21,210	39·6% 21,440	38·6% 21,630
Initial pressure, lb./sq. in.	610–650	610–640	610–660	580–650	610–650
Compression pressure, lb./sq. in.	570	590	580	590	590
Exhaust temperature, °F.	745	880	950	1,030	1,065
Exhaust colour	Invisible	Invisible	Invisible	Invisible	Invisible
Net brake M.E.P., lb./sq. in.	90·2	98·7	107·5	113	115

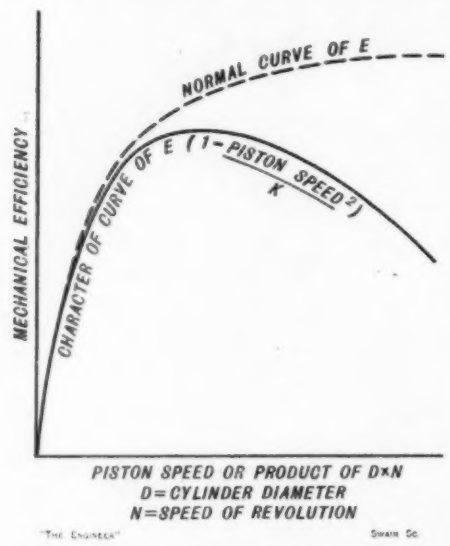

NORMAL CURVE OF E
CHARACTER OF CURVE OF E (1 − PISTON SPEED² / K)
MECHANICAL EFFICIENCY
PISTON SPEED OR PRODUCT OF D×N
D=CYLINDER DIAMETER
N=SPEED OF REVOLUTION
"The Engineer"
Swain Sc

Fig. 1—Speed and Efficiency Curves

stiffness in operation, even if it does not defeat the operation altogeter.

In this respect, as in the case of the normal working operation of the valves, the loading on a cam operating two small valves due to inertia effects may be only 60 per cent. of that on the cam which works a single valve of the combined area of the small valves. The smaller valves may be expected to give a freer passage to the incoming air, and thereby improve the volumetric efficiency of the cylinder. It will be seen, by exterpolation of the tests on supercharging that the normal volumetric efficiency of the cylinder is about 85 per cent.—an estimate that is confirmed by a number of tests with light spring diagrams.

Before leaving the question of mechanical efficiency, it may be advisable to remark on the power required to drive the blast air compressor.

Calibrations of small air compressors show that it is not sufficient to assume in the design calculations that a certain quantity of air at atmospheric pressure requires a given horse-power to compress it to a given pressure, as the efficiency of a compressor may vary considerably as the speed of revolution increases.

To pump 100 cubic feet of free air per minute to a pressure of 1000 lb. pr square inch in a particular compressor required 44 B.H.P. at 250 r.p.m., 50 B.H.P. at 320 r.p.m., 63 B.H.P. at 360 r.p.m., and 65 B.H.P. at 400 r.p.m. These powers, moreover, must be increased in the event of the compressor not delivering such quantities as a result of leakage through glands.

It follows, therefore, in the absence of precise information with regard to the air compressor proposed for use on an engine that it is possible to be 50 per cent. wrong in the estimate of power required if a low-speed air compressor be used for high-speed work. Such an error would entail encroachment on the available margin of power allowed in the cylinders in order to compensate for the compressor losses.

the general character of the performance of the Datic engine, which is undergoing extensive alteration. Although it is expected that the results will be improved upon materially, it is, nevertheless, probable that the general character of the efficiency curves will remain unaltered.

High compressions have been employed at times—rising from 430 lb. per square inch to 600 lb. per square inch in the case of the Digit engine—and rather higher in the Datic engine when it was doing its best, compressions of 700 lb. per square inch having been encountered in some of the preliminary tests.

The effect on the cylinder liner wear has not been at all marked—the wear of the four-stroke cylinder liners being of the order of one-thousandth of an inch on the diameter per 1000 hours' running—remembering that a considerable proportion of the running is under severe and even unsatisfactory conditions at times.

It cannot, however, be emphasised too strongly that, if the combustion conditions are not reasonably good, the laboratory experiences show that wear which can only be described as most excessive may be encountered.

The magnitude of the gas pressures that may obtain behind the piston rings, thereby causing heavy pressure between the rings and the liner may be referred to. Sundry attempts to cure this have been tried and the investigation is still being pursued.

In naval practice the number of piston rings ranges from about five to six in number as a rule, and an experiment based on the above-mentioned tests showed that it may not be wise to reduce the number of rings unduly. Whilst it would appear that three or even two rings are ample for gas-tightness, an undue reduction of piston ring surface tends to prevent the escape of heat from the piston to the water jackets and piston seizures may be expected.

Experiments show that it is imperative that the scavenge and supercharge air in the air duct be concentrated in a large volume in close proximity to the air ports in order to avoid the air having to travel unnecessary distances in the brief period available for the scavenging process.

As regards the injection of fuel, no material advance has been made on the methods described in the previous papers, the bulk of the work having tended towards the attainment of better scavenging of the cylinders at high speeds.

It is not wished in this paper to draw any comparison between the different types, except in so far as they are represented by the experimental engines at the laboratory, but it may be observed how much more readily the combustion processes are carried out in the four-stroke engines than in the two-stroke engines—even the Doxford engine, which gives the higher mean pressure of the latter, having an inherent tendency to detonate which may point to the degree of scavenging being inferior to that of the four-stroke engines. It may not be so, however, as two fuel valves are fitted and the shape of the combustion chambers are radically different.

On the other hand, when the air supply is supplemented by supercharging, the compression necessarily rises as the supercharge air pressure is raised, the result being a combustion of unusual smoothness.

As further experiments are in train with a view to improving the scavenging processes, it may be necessary to modify these views as additional experience is gained.

The thermo-mechanical difficulties have been serious at times, the overheating of the pistons in the two-stroke engines of several types tried being the most troublesome. Whereas in the four-stroke engines pistons of aluminium alloy have been in use for many years now, doing all that has been asked of them, piston heads of aluminium alloy have not been satisfactory in either of the two-stroke engines, on account of burning away or cracking. Cast iron also has failed for similar reasons, and the only piston heads which have shown signs of promise in the two-stroke engine are those with thin crowns of forged steel of an expensive character, in which every care has been taken to ensure that all portions of the crowns are equally well cooled as far as possible.

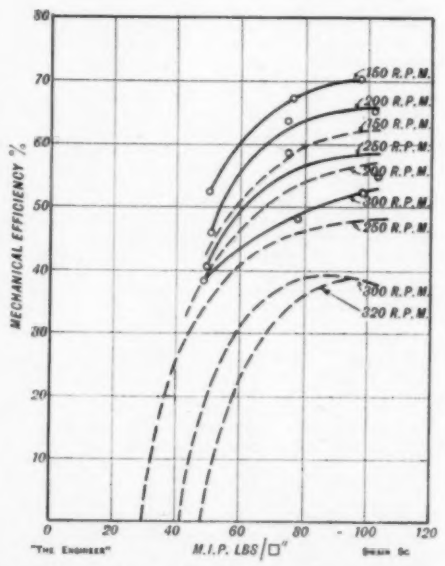
Cylinder liners with ports cut in them appear to be liable to cracking adjacent to the ports, which, whilst not at present of a serious nature, cause doubts as to the length of their working life when compared with that of the simple four-stroke liners.

Exhaust valves of alloy steels have been tried with a view to dispensing with the internal water-cooling arrangements in the valve heads and stems, and various degrees of success have been obtained.

Cracking of cylinder heads has ceased to be the bogey it was in the early days of the Diesel engine, and success has been obtained mainly by meticulous care in the design of the castings, and the strictest attention to ensure that all parts are well cooled.

Piston-rods of double-acting engines of nickel steel have so far behaved satisfactorily—the piston-rod packing, which is water cooled, consisting of cast iron rings, so fitted to the rod so that they may slide freely along it under the pressure of two fingers only, the result being a looking-glass polish on the steel. Lack of freedom for side movement has led to the firing-up and bending of one of the early rods, but with the rod trued up—it subsequently bent again—the packing behaved quite satisfactorily, although running trials with the rod bent.

The burning of a piston-rod caused some concern at one time, but on investigation it was clearly traceable to a crack in one of the pistons allowing the piston cooling oil to impinge on the surface of the rod, where its combustion



The full lines show results from G trial repeated after engine was fitted with new liner, pistons and scavenge pipes. The dotted lines show the results of the original G trial.

Fig. 2—Datic Engine Efficiency Curves

under uncontrollable conditions led to a violent attack on the structure of the nickel steel, which attack was attributed by the metallurgist to the virulent reducing effects of hot carbon monoxide on steel whilst under the combined conditions of high temperature and pressure.

At high piston speeds and high speeds of revolution, the piston cooling oil in the rod is apt to break under the inertia forces and cause a sharp knock in the piston cooling oil system, and experiments with a view to the prevention of this objectionable feature have met with some success.

The ordinary mechanical defects are limited in the main to the breakage of valves in air compressors and scavenge pumps, all working parts being supplied with forced lubrication. Some of the early air compressor valves had nicks

and sharp corners in them, and after ordinary care is taken not only to round off all corners, but to smooth them off as well, the breakage of a steel valve is almost unknown. Such care taken with brass valves of the Kinghorn type for reciprocating scavenge pumps failed to check the breakage, and they were replaced by valves of special steel which have worked satisfactorily.

Considerable work has been carried out at the laboratory in connection with the torsional vibration of the shafting system encountered with high-speed multi-cylinder engines when it may become serious and critical, difficulties having been experienced in the multi-cylinder engines on service which do not become of sufficient magnitude as a rule in single-cylinder engines to be noticeable, but space does not permit of much discussion on this subject at present, on which considerable experience has been gained.

A Simple Magneto.

FEW inventors appear to have tackled the problem of constructing a magneto on unconventional lines, or, at any rate, of dispensing with the revolving armature. A search at the Patent Office might, it is true, show that

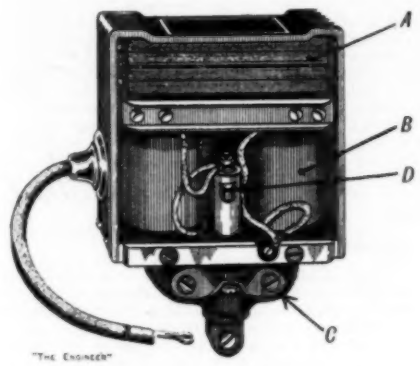


FIG. 1—"WICO" MAGNETO

this assumption is totally incorrect, but in any case the fact remains that the great majority of magnetos in use work on the well-known revolving armature principle. In America, however, a rather different type of machine has been in existence for a considerable time, and it is now being distributed in this country by The National Supply Corporation, of 165, Queen Victoria-street, E.C. 4. As the illustration Fig. 1 shows, the magnetic field is produced by permanent bar magnets A, the ends of which are attached to vertical pole pieces which carry primary and

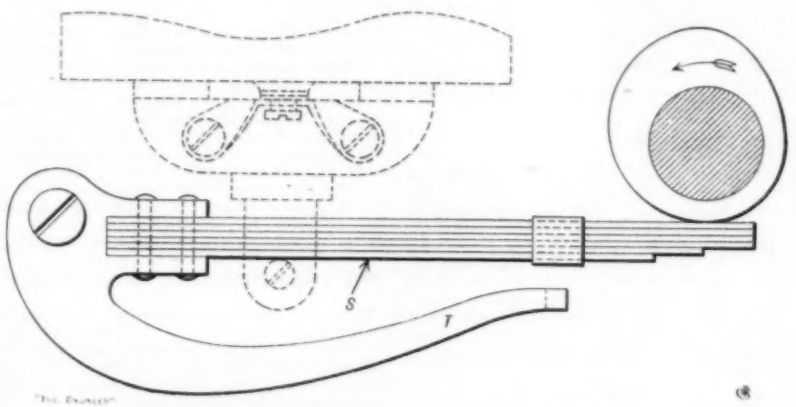


FIG. 2—SPRING OPERATING MECHANISM OF MAGNETO

secoadary windings B. At the lower ends of these pole pieces there is an armature C, and the high voltage is produced in the secondary windings by suddenly pulling the armature away from the pole pieces and by breaking the primary circuit by means of the contacts D. After the armature has been pulled away from the pole pieces it is replaced and the contacts are also closed, so that the machine is made ready for producing another spark.

It will be seen that, whereas the ordinary magneto has a revolving armature and contact breaker, this "Wico" machine has an armature and contacts that move in a vertical direction, the effect of separating the armature from the pole pieces being to cause the field to collapse. Owing to the fact that there are no revolving parts, the engine shaft is provided with a cam in place of the usual gear wheel, and the motion is imparted to the armature by means of a laminated spring S shown in Fig. 2. The spring, it will be noted, acts as a levor and serves to pull the armature from the pole pieces every time the high part of the cam makes contact with the right-hand end of the spring, which, as the speed increases, causes the spark to advance. Owing to the short time the armature is in contact with the poles at speeds above 250 revolutions per minute, the magnetic pull decreases, and consequently the deflection of the spring is reduced and the armature breaks away from the pole pieces at an earlier point in the rotation of the cam. The range of spark advance is progressive up to the maximum speed, and it is very easily controlled by the strength and length of the spring blades and the distance between the blades and check arm T. With a cam shaft speed of 750 revolutions per minute the automatic advance may amount to 30 deg. to 35 deg., which means that a very late starting spark can be given amounting to, say, 5 deg. after top dead centre, and as the engine revolutions increase and the load is taken up the spark will automatically advance to the correct position. For returning the armature to the pole pieces after the spark has been produced one of the spring leaves is extended partly round the cam, so that as the cam revolves the armature is pulled upwards as well as being forced downwards,

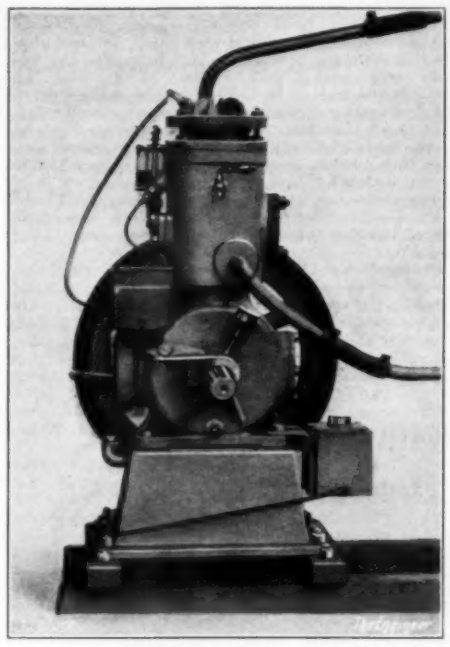


FIG. 3—ENGINE WITH WICO MAGNETO

but this arrangement is not shown in the illustration Fig. 2.

The "Wico" magneto is claimed to outlast the life of any engine, and it can be used under the most arduous conditions. It is oil, water, and moisture-proof, and experience is said to have shown that it will operate efficiently under all weather conditions. Other advantages claimed for the apparatus are that it gives a hot powerful spark independent of engine speed and it sparks regardless of high compression. Several well-known engine builders, we understand, are now using these magnetos, and an engine fitted with one and automatic spark advancing gear is shown in Fig. 3. The "Wico" magnetos on the market in this country at the present time are all for single cylinder stationary engines, but we understand that multi-cylinder magnetos will shortly be available.

The Gezira Irrigation Scheme.

IN what follows are given abstracts of two papers, both of them dealing with the Gezira Irrigation scheme, which are to be brought forward for discussion at the Institution of Civil Engineers on April 17th next.

"THE GEZIRA IRRIGATION SCHEME: CANALISATION OF THE GEZIRA."

By HARMOOD VICTOR CARRUTHERS JOHNSTONE, M. Inst. C.E.

That part of the Gezira plain which is suitable for irrigation lies between latitude 14 deg. north and Khartoum, being bounded on the east by the Blue Nile and on the west by the White Nile. The rainfall in the south-east of the area is about 400 mm. (15¾in.), which is generally sufficient for grain-crops, but it falls to 150 mm. (6in.) at Khartoum, where grain is grown only in years having more than the average rainfall.

The main crop hitherto grown was dhurra (*Sorghum vulgaris*) and also a small amount of the American kind of cotton; but under irrigation conditions each year one-third of the canalised area is sown under high quality Egyptian cotton, one-sixth of the area under dhurra for food for the cultivators, and one-sixth of the area under lubia, a leguminous plant, one-third of the area remaining fallow.

The population within the area is estimated to be 1·6 able-bodied men for each cultivator's unit of 30 feddans (1 feddan equals 1·038 acre), besides their families, and pilgrims.

The Scope of the Scheme.—The scheme described is the first part of a larger scheme. The total area capable of irrigation is about 3 million feddans, of which about 1·5 to 2 million feddans can be profitably cultivated. The present area canalised is 365,000 feddans, which has produced 302,258 feddans (approximately 100,000 feddans of cotton) of land under crop.

The design of the scheme is based on a maximum watering per feddan of cotton of 495 cubic metres of water every fifteen days, and of other crops of 480 cubic metres every twenty days measured at the head of the minor distributary. This gives the overall requirement at the head of the minor distributary of 19 cubic metres of water per feddan per day of twenty-four hours over the whole irrigated area, including fallow land.

After allowing for losses, the design of other canals is based on the following discharges per feddan of cultivable land dependent on the canal:—

Major distributaries	20 cu. m. of water per 24 hr. per feddan served	
Lower reaches of the main canal	21·65	do., do., do.
Head reach of the main canal	24·00	do., do., do.

The head reach of the main canal was therefore designed to carry 7·2 million cubic metres per twenty-four hours (84 cubic metres per second), sufficient to irrigate 300,000 feddans with a bed slope of 7 in 100,000, a bed width of 26 m., a depth of 3·4 m., and 1-to-1 side slopes, with a calculated mean velocity of 0·84 m. per second based on Manning's formula, the value of 1/n being taken as 50.

The second reach of the main canal was designed for the lower water factor of 21·65, but on the same formula and water-slope; all other canals were designed on Manning's formula on the assumption that 1/n is equivalent to 40. The designed bed slopes of canals conformed to the land slope as far as possible and varied from 15 to 5 in 100,000; and, except in the case of the main canal, the maximum discharge was 20 cubic metres of water per twenty-four hours per feddan served.

The canal alignments were designed to follow the ridges of the land, but the minor distributary canals were set out as far as possible parallel and 1415 m. apart to give a sufficient fall to the field channels and to facilitate agricultural control.

The masonry works generally had mass-concrete foundations and were faced with granite rubble mosaic. A grille of rails was embedded in the foundations of all but the smallest masonry works. Regulators were designed to a hydraulic gradient of 5 to 1, except at the group of regulators at kilom. 77, where the soil consisted of fine alluvial sand, and where a gradient of 10 to 1 was adopted. The limiting velocity in regulators ranged from 1·75 m. per second in main canal regulators to 1 m. per second in the smallest regulators.

The head-regulators of major distributaries were fitted with masonry weirs for constant and accurate measurement of water. They are of two types, clear overfall weirs where the available head was large, and standing-wave weirs where the available head was small.

Intermediate regulators are operated by horizontal timber stop-logs. Head regulators of minor distributaries consist of a steel pipe and valve, an open masonry well being built between the valve and pipe to obtain a uniform condition of discharge through the valve. Intermediate regulators on minor distributaries are similar in design except that a broad-crested weir was substituted for the masonry well.

Escapes were provided at three points on the main canal and at the extreme tail of the system, having masonry head-regulators similar to the main canal regulators. In one escape falls were constructed, but in the other escapes no falls will be constructed till the effects of the cutting action of the water have been observed.

Where the main canal cuts across the drain lines from the Gezira into the Blue Nile, the storm water of the larger drains is passed under the main canal in steel and concrete pipe siphons, but in the case of the smaller drains the storm water is passed over weirs into the main canal.

Construction.—Effective work was started in 1919 and completed (with the exception of 10,000 feddans which were opened in 1926) in July, 1925.

The area converted was 365,000 feddans, which produced 302,258 feddans of cultivable land. The works consisted of:—

The Main Canal, 114 kiloms. long.—Four main regulators, three escape-heads, twenty-six distributary head-regulators, two road bridges, one railway bridge, four storm-water siphons, nine storm-water weirs, five ferries, and seven cattle-watering ramps.

Distributaries, 1185 Kiloms.—Sixty-five masonry regulators, 551 masonry and steel pipe regulators, and 3800 field outlets.

Escape Channels, 26 Kiloms.—Four railway bridges, three road bridges, and two masonry falls.

There were also twenty-six permanent houses and offices, housing for menial staff, and 80 kiloms. of light railway.

The main items of work were 15,418,725 cubic metres of earthwork, of which mechanical excavators did 10,625,755 cubic metres; 47,827 cubic metres of masonry; 2003 tons of iron and steelwork; and 300 tons of steelwork in regulators. Thirty-one mechanical excavators of different types were employed, but the dragline type was found to be the most suitable, and other types were abandoned.

Good granite was available 125 to 140 kiloms. distant, and was transported by railway from the work dumps to the canalisation dumps. Cement was supplied from the cement factory at the Sennar Dam, an average distance of 100 kiloms., by railway from the canalisation dumps, and sand was obtained from the river. Materials were distributed throughout the area canalised by light railway, motor and animal transport.

Owing to difficulties in transport of material, and housing labour and protecting it from sickness, works (except mechanical excavation) were carried on only during the dry months, November to June.

Control of Water.—The following conditions had to be satisfied:—

(1) No field irrigation at night was possible.

(2) Disposal of water in excess of the actual requirements for cultivation was not possible after it had left the main canal.

(3) The actual requirements of the cultivating syndicate had to be satisfied.

(4) Measurement of water under varying conditions was necessary.

The disposal of water during the night is effected by maintaining the normal discharge continuously into the minor distributaries at the head, and storing the water in them by night by the following means. The canal banks were set well back, and a wide waterway is available. Regulators consist of a broad-crested masonry weir in which a regulating valve was built, and whose crest is 0·10 m. to 0·16 m. above the designed full supply level of the canal, the level being so fixed that, when running over the sill at maximum discharge, the water rises 0·30 m. above the full supply level of the canal. During the daytime, regulation is carried out on the valve, and the water is maintained at or below the designed full supply level of the canal, but at night all valves are closed, and the water is allowed to rise and flow over the weir, each reach being filled in turn from the head. A definite time when the last reach of the canal would fill is fixed, by calculation, and, allowing a factor of safety, irrigation of the field is suspended for this period. This period of storing varies according to the crop or field water factor from eight hours at periods of maximum demand to twelve hours when the demand is low.

The measurement of water is made on all main-line regulators and on the heads of all major and minor distributaries.

"SLUICES AND MACHINERY OF THE GEZIRA IRRIGATION SCHEME: BLUE NILE DAM AND CANALISATION."

By James Robertson Russell, Assoc. M. Inst. C.E.

The object of the scheme is to irrigate about 300,000 acres of the Gezira district of the Sudan, about 100 miles S.S.E. of Khartoum. The Sennar Dam, 3250 m. long, spanning the Blue Nile at Makwar, forms a reservoir from which water can be drawn when required into the main canal which carries it to the area to be irrigated. At the site of the dam a ridge of rock crosses the course of the river at no very great depth, and outcrops at one point to form a small island which divides the river into two channels. To prevent siltation, the silt-laden summer flood is passed through the dam with a low reservoir level, and the river above the dam is confined as much as possible to its normal channel. To this end the dam is pierced by eighty culverts, 2m. wide by 8·4 m. deep, each of which houses a sluice of the "Stoney" free roller type, very similar to those used in the Assuan Dam. The sluices consist of gates built up of mild steel plates and rolled joists working in cast iron frames built into the masonry. The water pressure is transmitted from the gates to the frames and piers through mild steel free rollers.

The gates are stanched by adjustable steel bars bolted to the skin plates. Suspension is by means of short link chains. These main sluices are operated by two petrol-driven machines which travel on tracks laid on the parapets of the dam. One of these machines is fitted with a revolving jib and is capable of operating a curtain which can close the mouth of a culvert should any of the sluices become jammed by logs or other obstructions.

The flow of water to the main canal is controlled by seven sluices similar in design to the river sluices, 3 m. wide by 5 m. deep, each sluice being operated by a separate hand crab.

The first of the groups of regulators that control the flow of water in the main canal and into the distributaries is 57 kiloms. down the main canal. In the main canal regulator at this point are six sluices of the double-gate type, fitted with circulating rollers. Each sluice is 3 m. wide by 5·05 m. deep. At the head of an escape channel to the river is a barrage of three similar sluices. Farther down the main canal, at kilom. 77, is a main canal regulator of four sluices and an escape regulator of three sluices, identical to those at kilom. 57. At kilom. 99 there are two sluices, and at kilom. 108 three sluices, all 3 m. wide, but rather shallower than the others. Certain of the smaller sluices in the northern area are of the sliding, non-roller type, operated by worm and rack gear.

It was expected that the sluice frames would have to be erected hurriedly during a few short periods, and special equipment was provided to enable the work to be tackled speedily and effectively whenever opportunity offered. This tackle was designed to deal with the tendency to spring which is common to all large machined iron castings and to facilitate their being brought into exact alignment. The plumbing gear was arranged to shield the plumb line and bob from air currents, and to permit of the detection of an error of less than 0·005in. Special slings and lifting bridles were provided to hang the frame castings from the crane hooks vertically or horizontally, as required. The frame castings were erected in recesses left for them, after the neighbouring masonry had been built, the spaces being then grouted up. During erection the sill castings were suspended in their recesses on screws by which they were levelled. Some difficulty was experienced in erecting the frames owing to the effect of the wide temperature variation.

The erection of the sluice work was commenced in the beginning of 1923. The first season's work, to July, 1923, was confined to the built-in parts of the canal head regulator and to the preparation of a suitable yard and workshop for the coming seasons.

During the second season the eastern channel of the river was tackled, and the masonry there was brought up to such a level that it should be exposed by the falling river in October or early November. This part of the work involved the erection of the lower frames of fifty-three main sluices. The eighty main and seven regulator gates were assembled and stacked in the yard ready to be transported to the dam and dropped into place in their frames when required. On the canals the groovework of the three regulator groups at kiloms. 57, 77, and 99 was completed.

At the beginning of the final season, in November, 1924, a very large part of the ironwork still remained to be erected. In the previous two seasons' work on the dam the frames of the seven regulator sluices and one-third of the main sluice frames had been completed, and the remainder of the work had to be finished in less than nine months to comply with the contract conditions and to enable the filling of the reservoir to be commenced in July, 1925. In the beginning of November the canal head regulator gates were lowered into place, and the lifting crabs, &c., were fixed in position. To test the results achieved with the somewhat elaborate plumbing gear, the stanching bars on the gates were actually tapped up to the groove faces—which had been scraped and greased—and bolted rigidly in this position. It was found that under these conditions the gates could be operated with ease. In December the erection of the frames of the main sluices in the east channel were recommenced, and of those in the west channel towards the end of January. In the middle of March the first main gate was lowered into position by the permanent jib machine. The sluice frames were completed by the middle of April, and the last gate was lowered on May 16th. By the end of June all the minor details had been completed.

The three regulator groups at kiloms. 57, 77 and 99 were completed by the end of January. The sluices at kilom. 108 and those farther north were erected in May and June.

On the dam the handling of the ironwork was facilitated by the construction by the main contractors of a gantry close to the upstream face. The heaviest of the frame castings weighed less than 2¼ tons, while the 7¼-ton gates were easily handled by the permanent operating machine.

South African Engineering Notes.

Power Schemes in South Central Africa.

The first unit of the new electrolytic zinc plant at Rhodesia Broken Hill, which is to produce 15,000 to 20,000 tons of zinc per annum, came into operation in January. The extended generating plant at Mulimqushi, 42 miles from the works, where the river has been dammed and a head of water of 1170ft. obtained, has been in operation for some weeks and power is now being supplied to the zinc plant. South Central Africa is likely, at an early date, to witness the erection of a number of large power projects for the exploitation of its mineral wealth. Work in connection with the installation of one large station in the Congo will commence very shortly. It is stated that the Union Minière du Haut Katanga has placed contracts for the erection of plant of 60,000 horse-power for the supply of electric energy to Pauda and other mines and plants on the great Congo copper belt. The equipment is to be built on the Lufira. The hydro-electric scheme will embrace four units each of 15,000 horse-power. Orders for three of these units have been placed with a Charleroi firm, and the order for the remaining unit has gone to the General Electric Company of Schenectady. The Roan Antelope Company—copper—in Northern Rhodesia also proposes to generate power from the Kafue River, and the company's engineers are said to be now engaged in working out the details of the scheme in London. From another source, however, comes the statement that while this idea was at one time seriously considered, further examination of the practicable sites has established the fact that such a procedure is inadvisable, and the project has therefore been dropped. Excellent coal from Wankie is available at a reasonable figure, and a steam turbo-generator seems suggested as the next best thing.

More Locomotives Ordered.

The order for thirty-nine large locomotives for the Union Railways has been divided, a British firm, the North British Locomotive Company, getting twenty-nine, and an Italian firm the remaining ten. The Italian price was, it is reported, lower than the British, but the remarkably quick delivery offered by the latter was the deciding factor. The total value of the order is about £250,000. It is expected that tenders for a further thirty-six engines will be called for at an early date. They will be of a smaller type, probably the 15 c., in which British locomotives on the South African Railways have gained a splendid reputation.

Platinum Revival.

The position of the platinum industry was entirely transformed at the end of January by the rise in the price of the metal in a few days from £14 to £17 15s., as the rise was taken to mean that a control body had been formed to handle the marketing and that the available stocks were in strong hands. It will be some time, however, before any of the platinum companies in South Africa will be able to market the metal in any large quantities. In addition to the three companies now producing—the Onverwacht Platinum, Ltd., the Lydenburg Platinum Areas, Ltd., and the Potgretersrust Platinums, Ltd.—there are only three or four others which have so far developed their properties that they have large quantities of ore of a good payable value proved. Of the three producing mines, the quantity of ore in the pipe which the Onverwacht is working are said hardly to warrant any extension of the existing plant, while with regard to the other two, although there are enormous quantities of good grade ore, production will not be begun until the metallurgical difficulties have been so far overcome that an economical recovery is assured. Precisely the same considerations actuate the other companies which have not yet erected plants; they are waiting until it has been decided what is the best process to install. A series of experiments with South African ore has been proceeding in America, while in England and Germany two of the largest metallurgical concerns have been experimenting on the ore, with results which up to the present appear to give promise of an extraction of 90 per cent. of the platinum group of metals. Locally, however, the Metallurgical Department of the Central Mining—Rand Mines Gold-mining Group has succeeded in obtaining results 5 per cent. better than those of the overseas chemists at what is stated to be a much lower cost. Moreover, the process discovered will, it is reported, enable shipment of the metal to be made from South Africa in bars, whereas the other processes would entail the shipment of concentrates or matte to Europe or America for further treatment. The initial cost of the plant for the new process is, it is stated, also likely to be very considerably less than that of the other processes. It is generally known that the oxidised ores of the mines in the Potgietersrust areas are, contrary to expectation, much more difficult to handle from an extraction point of view, than are the sulphides which are met with at a depth of about 80ft. There is little doubt, however, that the difficulties will be overcome in a manner similar to that which was successful with those which were met with in the treatment of the sulphides. The Eerstegeluk (Rustenburg district) ores have for some time past been treated in small quantities at the pilot plant of Potgietersrust Platinums, Ltd., and following the policy of co-operation which has hitherto been evident, these two companies are now practically in agreement as regards the erection of a new pilot plant thoroughly to test the best of the three processes discovered. It is understood that no delay will take place in the erection of the first unit of this plant, and that it will be in working operation before many months have passed. Should it do all that is expected of it, a joint plant will be constructed to deal with both ores on a considerable scale. This, however, is unlikely to happen for at least a year, and the price of platinum will then, to a large extent, govern the policy as to the scale on which operations will be carried on. As a matter of fact, the situation is that none of the platinum companies are in a position to take immediate advantage of the advance in the price of the metal. Those at present producing can increase the output somewhat no doubt, but the controllers of the principal concerns are determined to take no risks, but to proceed quietly with a settled policy of endeavouring to build up the industry on a sound and sure foundation. The resources of the metals of the platinum group of mines in the Transvaal are phenomenal—and they will probably be working hundreds of years hence—but as far as the present demand can be gauged, these supplies will not be required to be won in very large quantities for some years to come.

Railway Finances.

The Auditor-General of the Union, in his report on railway accounts for 1926–27, makes an interesting comparison between the operating ratio on the South African Railways and several oversea railways. Operating ratio, he explains, is the percentage of gross earnings required for operating expenses. A high or rising percentage, therefore, apparently denotes expensive or wasteful management. On the German State Railways it was 70 per cent. before the Great War; in 1925 it was 85·5 per cent.; but they are now striving to get it down to 80 per cent. On the Canadian National Railways the operating ratio came down from 97·7 per cent. in 1922 to 86·83 per cent. in 1926. In the United States, on the South Pacific Railway, the operating ratio came down from 78·88 in 1921 to 73·88 in 1926; and on the Pennsylvania Railways it sank from 87·56 in 1921 to 77·52 in 1926. On the South African Railways the operating ratio in 1911 was 60·4 per cent. It rose to 76·4 per cent. in 1914, dropped to 53·7 in 1916, but rose again during the latter part of the war. Since the war the lowest ratio was 74·0 in 1924. During the last three years it has steadily risen to 80·67 per cent., and the Auditor-General remarks that "the tendency is upward." The increase last year was 3·09. Although the year 1926–27 commenced with a surplus on revenue account of £764,506 carried forward from the previous year, the year 1926–27 ended with a deficit on revenue account of £136,966. The deficit has been financed out of the £450,000 to the credit of Rates Equalisation Fund. The interest-bearing capital invested in the railways at the end of March, 1927, was £139,539,787, and the non-interest bearing £9,117,747. The earnings totalled £28,012,087 and the expenditure £28,463,560.

THE INSTITUTION OF WATER ENGINEERS.

The thirty-third summer general meeting of the Institution of Water Engineers will be held at Torquay on Tuesday, Wednesday, Thursday and Friday, June 12th to 15th, inclusive. By permission of the Mayor and Corporation of Torquay, the meetings will be held in the Reception Room, Town Hall. The following programme has been arranged:

On Tuesday, June 12th, starting at 10 a.m., a visit will be paid to H.M. Dockyard, Devonport.

On the Wednesday, at 10 a.m., there will be a general meeting, when an official welcome on behalf of the Borough of Torquay will be extended to the Institution by the Mayor of Torquay. The chair will then be taken by the retiring President, Dr. Herbert Lapworth, M. Inst. C.E., F.G.S. The programme of business will include the presentation of premiums awarded by the Council for papers presented during 1927; the installation of the new President, Mr. Samuel Christopher Chapman, M. Inst. C.E., Water Engineer to the Corporation of Torquay, and the reading of his presidential address. Discussion on papers will follow. In the afternoon there will be a motor coach drive, at the invitation of the Corporation, and tea will be taken in the Abbey Park, at the invitation of the Mayor. The twenty-ninth annual dinner of the Institution will be held at the Victoria and Albert Hotel, Torquay.

On the Thursday visits will be paid to the Burrator Reservoir of the Plymouth Corporation, and to the Venford Reservoir of the Paignton Urban District Council, and in the evening the Mayor and Mayoress will give an "At Home" at the Medical Baths.

On Friday, June 15th, the general meeting will be resumed at 10 a.m., when the discussion on papers will be continued. In the afternoon a visit will be paid to the Tottiford Reservoir of the Torquay Corporation. The following papers, which, to afford time for discussion, will be taken as read, will be submitted to the meeting:—(1) "The Torquay Waterworks," by Mr. R. V. Toms; (2) "Average and Extreme Seasonal Rainfall Over the British Isles," by Dr. John Glasspoole; (3) "The Water Supply of Lourenco Marques, Portuguese East Africa," by Mr. R. H. Fox; (4) "Water Supplies as Future Sources of Power," by Messrs. R. F. Legget and A. L. Lyon.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Easter Influences.

THE approach of the Easter holidays has undoubtedly had considerable influence on trading conditions in the iron and steel market this week. Works evidently have sufficient material in hand to recommence after the holidays, for few consumers are negotiating for further supplies. Merchants report that inquiries have been much below the average. Many of the Staffordshire works will have three days' holiday next week, while others will be idle during the whole of the week. When work is resumed a better run of business is anticipated, there being improved reports from many of the Midland and Staffordshire consumers of iron and steel.

Pig Iron Prices.

The pig iron trade continues poor. Demand expands but slowly, and it is common knowledge that the Northamptonshire smelters are no longer holding out for £3 for No. 3 foundry iron. Nominally, £3 is the quotation; but it is reported that transactions have taken place at £2 19s., and even £2 18s. 6d. With specifications lagging considerably, furnacemen are naturally uneasy about the disposal of their output, and the weakening tendency of prices is not surprising. It is reported on 'Change in Birmingham that the basis price of £3 4s. for Derbyshire has been shaded. However this may be, the market is decidedly weak from the point of view of demand. Furnacemen generally are firm in their quotation of £3 4s. The call for forge iron is poor. The Black Country forges have apparently satisfied their requirements in the way of forge pig iron for some time. Quotations in this department are unchanged.

Blast-furnace Coke.

Many blast-furnacemen in the Midlands are of opinion that when the scheme for restricting output in the coalfields has been set going, blast-furnace coke values will rise. In some cases they have taken precautions against such a contingency. There are many other furnacemen, however, who refuse to add to their commitments in the present uncertainty of the pig iron market. There is so little prospect of the smelter getting indemnification for any increased cost, and so much of the business now passing is unremunerative, that the alternative of damping down furnaces is talked of.

Staffordshire Bars.

A fair demand is maintained for marked bars, at the basis of £12 10s., and for special quality iron for chains and cables. Mills are, however, only kept going by relatively small orders, of which prompt execution is required. There is no satisfactory reserve to steady the trade. Considerable disparity still exists in the rates of unmarked bars of Crown quality. Staffordshire and Lancashire houses quote £10 to £10 5s., but makes from other districts may be bought at £9 5s. upwards. Common bars, such as are used in the manufacture of nuts and bolts, are said to be obtainable at £8 17s. 6d., but most Staffordshire makers continue to quote £9. A new competitor from the Continent is a form of wrought iron described as "best best," which costs considerably more than the Belgian ordinary No. 3, and is claimed to be a pure iron of the Staffordshire brand, and is sold to some extent for the manufacture of horseshoes. Wrought iron gas tube strip commands £11 10s. per ton. Staffordshire ironmasters on 'Change in Birmingham this week expressed a decided conviction that engineers in increasing numbers are preferring old-fashion wrought iron gas and steam tubes to those made of steel, although there is not enough business to keep the makers of gas strip busy.

Sheet Values.

Midland galvanised sheet mills have been unable to uphold the minimum price of £13 5s. per ton for 24-gauge galvanised corrugated sheets. This week the minimum has been back at £13 2s. 6d., though that is half-a-crown less than some of the mills are prepared to entertain. Galvanised sheet manufacturers are not disposing of their output so far ahead as they would like, though many of them are fairly employed, and have enough orders to assure activity for some little time. There have been more promising inquiries from South America; and good business is anticipated from that quarter. Large consignments for South Africa have been awaiting an opportunity for cheap transport. The freight war between rival shipping interests is still being waged, and the competitive rates quoted necessarily condition a great deal of the business. The call for black sheets is improving.

Steel.

The steel position shows very little change on the week, but it is noticeable that many of the district mills are making nearly full time, though they are still under the disadvantage of making frequent roll changes. Individual orders are small, but fairly numerous. Angles, joists and plates are in quiet request, and quotations are unchanged from those lately ruling. District strip mills continue in better employment. Quotations run from £7 10s. upwards. Orders have been accepted for small steel bars at £7 5s., but as a rule sellers ask £7 7s. 6d. or more. Wire rods rolled from British billets are easier at £8 15s. When imported billets are used the price is £8 2s. 6d. Continental prices have not recovered altogether from the relapse last week, but they have steadied. Midland industrialists who have watched the foreign market closely of late find it difficult to reconcile the reversal of recent market tendencies with the reports of a great consumptive demand behind the price movement of last month. The effect is discouraging on some branches of the trade in this country, which have been doing rather better of late. However, it is contended in some quarters that the effects of the solicitude of Antwerp shippers to tighten their hold on the British trade have been but limited, and that there are indications that less use is now made of foreign steel in building, as the combined result of the rebate system and the increase in foreign prices.

Demand for Scrap.

The greater firmness of pig iron has led to an increased demand for scrap, which is now selling at £3 2s. 6d., delivered in South Wales. Sales of this material have been decidedly heavier lately.

Foreign Competition in Iron and Steel.

The burdens under which the iron and steel industries of this country are working, suggestions for endeavouring to lessen them, and the future prospects of the industries were dealt with by Colonel Trinham at the annual meeting of the Midland Iron and Steel Wages Board, in Birmingham last week. Prices throughout the year had, he said, continued to droop, and the quantities of material manufactured had fallen. The return on capital invested in the iron and steel industry in the United Kingdom was poor, in Germany fair, in the United States and France considerable, and in Belgium very high. Why should Belgium, whose prices were the lowest, have a very high return on capital? He had seen up-to-date ironworks in Belgium and France built on the site of old works destroyed by the Germans. The rebuilding costs had been largely, if not entirely, borne by Government. It was not necessary to emphasise the influence, very well known to the meeting, which the importation of foreign material had upon the basic industries of this country, and particularly in the wrought iron trade. Those associated with the basic industries knew the effect of the lower taxation, the much smaller extent of social services, and the lower wages and longer hours which obtained on the Continent. He said without hesitation that the ability and enterprise of the employers generally and the character and ability of the British worker, other things being equal, would put them in an absolutely unassailable position; but they had to take things as they found them. The employers might make endeavours to alter things needing amendment, but they had no power elsewhere, and they thought the operative side could possibly exert a greater influence than the employers in those matters. The trade must make the best of its own abilities, its own brains and inventions.

Ironworkers' Wages.

Ironworkers' wages which are regulated by the sliding scale under the Midland Iron and Steel Wages Board are to remain unaltered during the next two months. Recent bi-monthly ascertainments have resulted in falls in wages, and workers in the industry express pleasure that on this occasion selling prices of iron and steel have not dropped sufficiently to warrant a dimimution in the percentage rate paid to those employed in the industry. Until June wages will be calulated at 32½ per cent. above the puddling base rate of 13s. 6d.

Coal Marketing Scheme.

All the Cannock Chase coalowners who have joined the Midlands marketing scheme have, I am given to understand, now signed the articles governing the trust, and the scheme began to operate on Monday of this week. Three collieries in the Cannock Chase area still remain outside the combination, but those which have adopted the plan represent 80 per cent. of the total coal output of the district. Each colliery in the area has been allocated its quota of coal to be raised during April, and it will remain with the companies to adjust their working days accordingly. There continues to be a brisk demand for coal in the Cannock Chase area, and the collieries are cleared out of practically all pithead stocks. Prices are stationary for the moment, and there is no immediate prospect of readjustment. I learn that negotiations are proceeding for the adoption of the marketing scheme in the South Staffordshire coalfields in the near future.

Miners' Wages.

The wages of Cannock Chase and Pelsall miners for April, which are based on the results of the local coal industry during the months of December, January and February, will remain, for the tenth consecutive month, at the minimum of 42 per cent. on basis rates, although the owners' real ability to pay is only 15·09 per cent., compared with 11·54 per cent. a month ago. A stallman's minimum wage, therefore, continues at 9s. 4d. a shift. The loss per ton of coal raised during February was 5·35d., against 0·93d. in January and 9·32d. in December. The accumulated deficit is now stated to be £1,429,223, compared with £1,283,330 at the end of February, £1,116,305 at the end of January, and £928,764 at the end of December.

Unemployment.

Further improvement in the unemployment situation in the Midlands is shown this week by the official returns. Following a decrease of 6043 recorded last week and decreases of 456 and 4326 in the two preceding weeks, the current total of 124,607 reflects a substantial drop on the week of 4078. The Birmingham figures are now down to 23,697. Conditions in Coventry have improved slightly, the total of 2974 being 219 fewer than that of the previous return. Increased unemployment is reported from Bilston, Cradley Heath, Northampton, Walsall, and Wednesbury.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

The Industrial Outlook.

A RATHER more favourable view of the outlook in the engineering trade is taken by the Manchester Chamber of Commerce in the course of its usual monthly survey of general industrial conditions. Discussing the position during the past month, it is pointed out that the engineering trade, taking it as a whole, has done fairly well. Textile machinists are not getting as much home business as they would like, but they are now more hopeful than they have been. Some makers of machinery for the production of artificial silk are well employed, and one good order for woollen, spinning and combing machinery for France has been received. Lancashire looms are in demand, and at least one firm of makers has been working overtime, but even then had to decline a contract for Jacquards for the Continent on the ground that delivery could not be given at the specified date. Electrical machinery contractors are not well engaged, but every section of the small tool trade is doing more work than for some time past, as business is not so restricted to the requirements of motor manufacturers.

Coal Trade's Hope.

The coal trade, it is pointed out, continues dull. Most of the collieries in the Manchester area are on short time, but, even so, the owners find that stocks are accumulating, and buyers have been able in some cases to get supplies at less than current quotations. The trade's hope is that the combination to subsidise exports will enable coalowners in other counties to ship more to foreign markets and, as a result, send less to compete with Lancashire fuel. At present the best house coal finds a poor market in this district.

Non-ferrous Metals.

Although the rate of improvement of the two previous weeks has not been maintained, the tin section of the non-ferrous metal market has continued to give a fairly satisfactory account of itself from the point of view of prices, which has registered a further steady advance compared with the values current a week ago. There seems to be no doubt that the statistical position of the metal is much more bullish in sentiment. Stocks in this country have shown a steady decline during the past few weeks, and although the demand has been less pressing than in the previous week, prices have displayed a reasonably steady tendency, and on balance are higher by £1 or £2 a ton, according to position, compared with the values ruling at the time of my last report. In the case of copper the position has been relatively firm. Cable makers have been buying in fairly satisfactory quantities, and in sympathy with movements in the United States markets prices have moved up to some extent compared with a week ago. Interest in the lead section has been on moderate lines, and prices have kept about steady on the week, although, in view of the possibility of increased supplies being available again before long, the undertone can hardly be described as strong. There has been no lack of spelter to meet the demand in this section, and quotations have lost ground on the week to the extent of a shilling or two a ton.

Iron.

Except that the tone of the foundry iron market here is, if anything, quieter than before, there has been little to distinguish business conditions during the past week from those of any of its predecessors of the last month or two. This experience, however, has not surprised sellers, who are usually more or less resigned to a dull spell just before a holiday stoppage, although in this case, so far as the majority of local foundries are concerned, the actual interruption of operations will not extend to more than a day or two at the outside. Another factor which has been put forward recently as being partially responsible for the prevailing quiet conditions in the pig iron market, is the forthcoming quarterly meeting at Birmingham. Some buyers in this part of the country are believed to be biding their time until this event is over. There has been a certain amount of inquiry in circulation during the week, but there is a tendency on the part of sellers to regard the bulk of this as being in the nature of "feelers." Meanwhile, quotations have been well held in most sections of the market, and in this respect little change of any importance has to be recorded compared with a week ago, offers of Derbyshire No. 3 ranging from 72s. to 72s. 6d. per ton, for delivery Manchester or equal distance, Staffordshire being quoted at 71s. 6d., North-east Coast brands at 79s., West Coast hematite at 84s. to 84s. 6d., and Scottish pig iron from 87s. 6d. to 90s. per ton. Lancashire manufacturers of bar iron are unable to do more on the basis of the existing demand for their products than keep their plant running at about 50 per cent. of its capacity, users' commitments being confined to comparatively small parcels. Values keep steady, however, Lancashire Crown bars being quoted at £10 per ton, and second quality at £9 10s.

Steel.

Local constructional engineers in most cases are fairly actively employed on work in hand, although in view of the continued quietness during the past month so far as fresh inquiries are concerned, they are unable to see so far ahead at the moment as they have been at any time during the last six months or so. They are still, however, buying a fair tonnage for prompt or early delivery, and continue to be the mainstay of the market here. Except for occasional bright spots there is not very much business passing in the aggregate in the case of boiler-plates, and the demand for both large and small steel bars is patchy. For the most part, however, quotations are steady all round, joists and sections being at £7 17s. 6d. per ton, ship and tank plates at £8 12s. 6d., boiler-plates at £9 15s. for basic, and £10 to £10 5s. for acid plates, large steel bars at £8 17s. 6d., and small re-rolled bars at from £7 10s. to £7 12s. 6d. The demand for imported steel is rather slow, and buyers on this market, in view of the renewed easiness in this section, are operating very cautiously. For delivery to works in the Lancashire district, with net cash against shipping documents, continental wire rods are at about £6 15s. per ton, ordinary plates at £7 4s. to £7 5s., Siemens plates at £7 15s., sections at £5 15s. to £5 16s. 6d., angles at about £6 5s., sheet bars at £5 10s., and billets at £5 5s. per ton.

BARROW-IN-FURNESS.

Hematite.

There is still a state of general slackness in the hematite pig iron trade in this district, and customers are

still confining their orders to immediate requirements. There are some customers who used to deal with this district who have not been placing many orders of late, and that fact inclines one to imagine that iron is being bought elsewhere. The Midlands are taking the heaviest tonnage, but the deliveries, as a rule, are light compared with those of a normal period. There is a little continental business, but it does not amount to a great deal. Stocks still exist at works which stopped production some time ago, but they are being slowly reduced. Ulverston will probably put in a furnace shortly. It is not producing any iron at all at present. Fortunately the steel departments have been taking a goodly proportion of iron, otherwise there would have been reduction of output some time ago. During the Easter holidays, when the steel departments close down for the holidays, stocks will increase at Barrow. The iron ore trade is moderate. Most of the ore is being taken by local ironworks, but there are deliveries of better qualities to outside customers. The steel trade is quiet, and not many orders are held, and that is why there will be a spell off for the Easter holidays. The Barrow mills have, however, had a very good run, and, considering the condition of the market, have been fortunate in securing a succession of orders which have enabled them to be in constant work for over a year.

SHEFFIELD.

(From our own Correspondent.)

Condition of the Steel Trade.

Although some special branches of the steel trade—notably that concerned in the production of stainless material—show prospects of continued progress, there is no evidence of general expansion. There has actually been a falling off in the demand for raw and semi-manufactured iron and steel, in spite of the fact that continental prices remain high, and that some classes of British material are as cheap as foreign. The amount of work being done in many of the finished sections is large, but it is difficult to obtain remunerative prices. The chairman of Henry Bessemer and Co., Ltd., stated last week at the annual meeting of the company that conditions in 1927 nearly approached the ideal as regarded volume of business, but the ideal was shattered by the never-ending fall in the prices they had to take. Their production of steel was roughly 50 per cent. greater than in 1925, their last normal year, but owing to intense competition the profit per ton was much less, and had it not been for the new plant that they had now at work they would have made a loss instead of a profit. He added that this year they had already found themselves short of work, and that, although much was stated in the newspapers about the revival of trade, he personally did not see, in railway traffic returns, any particular evidence of such revival. There is a fairly good demand for files and various classes of tools, but the absence of Russian trade makes a big difference. If orders from that market were up to the normal level, the factories would be really well employed. For some time there has been a steady expansion in the small tool department, but here, again, prices are low and little profit is to be earned.

Vickers' Improved Year.

The chairman of Vickers Ltd., at the shareholders' meeting last week, was able to give a good account of the firm's year at Sheffield, but he also complained of low prices. Although the year 1927 did not fulfil expectations at Sheffield, he said, trade was, nevertheless, sufficiently good to enable them to keep the major part of their plant fairly well employed. During the year they turned out about 100,000 tons of steel, which was a greater production than they had had since 1918. They had recently made the largest and heaviest ingot which had ever been produced at the River Don Works, weighing 165 tons, and orders had been obtained for a class of large forgings which they were hoping would enable the heavier plant to be kept more fully occupied. In the tank department they had not had many orders, but it had been employed to a certain extent on experimental equipments for the British Government. At the present time Vickers-Armstrongs were making two important equipments which had just been adopted, and they were hoping that this would lead in the near future to substantial orders. They had commenced the manufacture of armoured cars, and had turned out thirteen during the year. In the stamping department the total order sheet for the year was one of the largest since 1920. "Although at Sheffield," he added, "we had more work than in the previous year, the profits were less than we hoped, owing to the fact that we had to take many orders at very low prices."

The Local Rate Burden.

The heavy burden which high local rates impose on industry has been referred to on many occasions by chairmen of large companies. It was again brought forward by Sir Herbert Lawrence at Vickers' meeting, when he referred to it in a serious manner. "During the past year," he said, "the total local rates at our works and those of our subsidiary companies constituted a heavy item of expense, the contribution at Sheffield alone being £56,669. If this burden increases, we shall have seriously to consider whether it will not be to our advantage gradually to transfer our production to centres where the rate burden is less onerous, for the heavy local taxation falls not only on the company directly, but also on the employees at the works in the district."

Armament Work.

Although there has been a heavy fall in the manufacture of armaments since the war, the trade is still a substantial one. The King and Queen of Afghanistan visited Sheffield during the past week, and in the spectacles provided for them at the works of Vickers Ltd. and Hadfields Ltd., munition production played a considerable part. The rolling of an armour plate was seen, and other work on hand included armoured cars, guns and projectiles for aircraft and coast defence. On this point perhaps I may be permitted still another quotation from the speech of the chairman of Vickers Ltd. Speaking of the company's prospects, he referred to the extent to which their interests were connected with armaments. They had, he said, to face the possibility of a further limitation of armaments, and, despite any development of their commercial business which they could bring about, the result in the event of more reduction in armament orders would be a serious one for the company.

Tender for £8,000,000 Scheme.

Mr. Charles Boot, of Sheffield, chairman of the Sheffield and London firm of Henry Boot and Sons, Ltd., builders and contractors, went to Athens a few weeks ago personally to submit to the Greek Government his firm's tender for large schemes of irrigation and reclamation in Macedonia and Thessaly. It is now announced that Messrs. Boot's tender was 5 per cent. lower than those of their nearest competitors among whom were the American firms, John Monks and Sons, Ulen and Co., the Foundation Company, and also the Ægean Trust, Ltd. Mr. Boot, in a letter from Athens, states that his firm has submitted proposals for the establishment of model farms in each of the districts embraced by the scheme. The communications will be ameliorated by the establishment of a new road system. Reclamation is to be achieved by the provision of ample outlets to the sea for the rivers which now run in channels that have become congested. In some cases it has been decided to cut new channels for the river bed, and in one instance the conclusion has been come to that the best way to evacuate the water is by means of a tunnel, 7 miles in length, through the Pilaf-Tope Mountain. "These operations," says Mr. Boot, "together with the subsequent irrigation of the reclaimed land, call for experienced engineering skill, and we are fortunate in having secured the services of Sir Murdoch Macdonald and Partners, whose wide knowledge of this work, linked with the modern resources and organising ability of experienced contractors, will be fully equal to undertake the solution of the many problems which will be involved." Should Messrs. Boot's tender be accepted, large orders for Sheffield works would result.

Large Tramway Contracts.

Considerable extensions of tramway facilities in Sheffield are proposed, and the Tramways Committee recommends acceptance of large contracts involving an expenditure of many thousands of pounds. Steel, Peech and Tozer, Ltd., of Rotherham, are to supply 1000 tons of rails at £9 17s. 6d. per ton. From Cravens Railway Carriage and Wagon Company, Ltd., Sheffield, are to be obtained twenty-five car sets of tramcar upholstered seating, at the rate of £157 10s. per car set; twenty trucks, complete, at £220 each; five trucks with roller bearings, at £278 each; twenty-five sets of control and braking system, erected, at £205 per car set; and twenty-five sets of control and braking system, not erected, at £182 per car set. W. and E. Hill, Ltd., are to provide twenty-five double-deck top-covered vestibule tramcar bodies erected complete on trucks at £1190 each; and the Brush Electrical Engineering Company, Ltd., twenty-five tramcar trucks, at the rate of £152 net each. Contracts for electric equipment are to be let to the British Thomson-Houston Company, Ltd., the Electro-Mechanical Brake Company, Ltd., Metro-Vickers Electrical Company, Ltd., and the General Electric Company, Ltd.; and for trolley standards to the Malleable Steel Castings Company, Ltd.

Staveley Colliery Development.

The Staveley Coal and Iron Company, Ltd., has now completed extensive developments at its Markham No. 1 and No. 2 collieries, which have been in progress for a year, and everything is in readiness for the opening up of the Black Shale seam as soon as trade revives. The company has decided to work this seam, which was reached at a depth of 700 yards, after a close examination of other seams passed through on the way down to it. Plant capable of dealing with a big output, and including a new washer and screens, has been erected, but it will not work at full pressure while the coal trade is in its present state.

Electrical Extensions.

Excellent progress continues to be made by the electricity undertaking of the Doncaster Corporation. Between 1920 and 1925, turbo-generators of an aggregate capacity of 6000 kilowatts, and a steam-raising plant, were installed at a cost of £107,000. It soon became necessary, however, to provide still further generating machinery, and an extension to cost £63,000 was sanctioned two years ago. The first section of this extension, now completed, includes a turbo-generator with a capacity of 7500 kilowatts, which was officially started last week. The second portion of the new works, which includes the provision of two water-tube boilers, is under construction, and the plant will commence work in two or three weeks.

NORTH OF ENGLAND.

(From our own Correspondent.)

Iron and Steel Exports.

There is still a very hopeful feeling in iron and steel trade circles, though progress towards a normal state of activity continues very slow. No longer is foreign iron underselling Cleveland iron in the home market, and though continental semi-manufactured materials are cheaper in some instances than British, the rebate system has very largely excluded continental plates and sections from the home markets. On the other hand, the export trade shows no real improvement; indeed, the Cleveland area is selling less steel abroad than it was this time last year. Over the whole of 1927 the average monthly exports of manufactured iron and steel exceeded 71,000 tons, whereas for the first quarter of 1928 it has been no more than about 62,000 tons, and the March shipments of 62,257 tons fall 4613 tons short of those of February, notwithstanding the longer working month. The best feature of the March returns is the fact that the pig iron shipments are the biggest recorded since the coal strike, totalling 20,318 tons, as against 18,411 tons in February. The exports of Cleveland iron to foreign destinations are still relatively small, and amounted last month to 11,106 tons, but only once before in the last fifteen months have they exceeded 11,000 tons. Further progress, however, is looked for, and it is significant that another blast-furnace was put into operation this week on the production of Cleveland iron at the Skinningrove Ironworks.

Big Drop in Iron and Steel Imports.

The success which has attended the efforts of Cleveland iron and steel manufacturers to combat foreign competition is reflected in the statistics of imports to the river Tees presented at this week's meeting of the Tees Conservancy Commission. During the past five months the imports of all descriptions of iron and steel only totalled 89,016 tons, as compared with 179,303 tons in the corresponding five months of 1926–27 and 31,266 tons in 1913–14. A feature is the great drop in pig iron imports. Owing to a rise in the price of continental iron due to increased costs of production, Cleveland makers have been getting a greater share of the home trade, with the result that the imports during the past five months reached only 4071 tons, as against 66,303 tons in the corresponding period of 1926–27, and 54 tons in 1913–14. Plates, bars, angles, rails, sheets, joists, &c., imported totalled 17,745 tons, as against 25,318 tons in 1926-27, while 67,200 tons of crude sheet bars, billets, blooms, slabs, &c., were unloaded, as compared with 87,682 tons and 19,970 tons respectively.

Cleveland Iron Trade.

Although the note of confidence which has characterised the Cleveland pig iron trade for some months past has not departed, there are some disquieting features at the moment, and business is not so brisk as it was a week or two ago. The situation, of course, is often marked by listlessness just before the Easter holidays, but the disinclination this week of customers to negotiate at all extensively for forward supplies, with the shadow of returning continental competition, is discouraging. While prices of foreign material are not attractive, they are easing, and the revelation that manufacturers abroad have less satisfactory order books than was supposed, is causing some uneasiness. Early resumption of formidable foreign competition is not looked for, but the fact that some overseas firms are prepared to negotiate for contracts for fairly early delivery is not cheering. Transactions in Cleveland pig iron are less easy to arrange than of late, but delivering demands against running contracts are on a heavier scale than can be satisfied by the limited output, with the result that stocks are still being reduced. The requirements of ironmasters' own foundries and steel works are heavy, and local pig iron consumers who have to buy in the open market are taking considerable supplies. Hope of continued business with home customers at a distance is entertained, but there seems little prospect of early material expansion of the very limited export trade. Quotations are firmly maintained, No. 1 Cleveland foundry iron being 68s. 6d.; No. 3 G.M.B., 66s.; No. 4 foundry, 65s.; and No. 4 forge, 64s. 6d.

Hematite Pig Iron.

Improved conditions are reported in the East Coast hematite pig iron trade, though production is excessive and quotations unremunerative. A fair number of home and continental inquiries is circulating, and sales are less difficult to put through. Prices continue to vary a good deal, but the tendency is upwards. Ordinary brands are little sought after, but the quotation for mixed numbers of 70s. still rules recognised market rates, though while parcels of certain makes are obtainable on a lower basis, there are brands that command higher terms.

Ironmaking Materials.

The prolongation of the Swedish ore miners' strike is now having its effect on the foreign ore market, and supplies are not so freely offered. Consumers, however, are well stocked, and are receiving good deliveries from Bilbao under running contracts. Values are firmer, best Rubio ore being fully 22s. 6d. per ton, c.i.f. Tees. Blast-furnace coke is only moderately taken up by local users. Good medium qualities are in the neighbourhood of 18s. per ton delivered at the works.

Manufactured Iron and Steel.

There is no new feature of moment in the manufactured iron and steel trade. A good output is being maintained, but some departments are needing new orders. Values are unaltered.

Coal Trade Proceeds and Costs.

The second month of the operation of the recent miners' wages awards in Northumberland and Durham shows better economic results, as calculated through proceeds and costs, but there are still deficiencies to be made up by the colliery owners. The Northumberland deficiency is now down to about 2¼ per cent., but in Durham it stands at the high figure of over 22 per cent. In Northumberland the proceeds and costs in February, which would regulate wages in April but for the operation of the minimum clause in the county agreement, indicate that the wages payable would be at the rate of 37·42 per cent. on the basis as against 31·09 in March, an increase of 6·33 per cent. As the minimum percentage is 40, the rate of wages will be unaltered, and the deficiency to be made up by the colliery owners will be 2·58 per cent., the lowest but one that the owners have had to face since the county agreement came into force at the beginning of last year. The improved yield may be due to two causes, namely, the effect of the steady minimum prices for coal in February and a reduction in the cost of production. The ascertainment for Durham shows that the proceeds and costs in February would provide for a percentage on basis wages in April of 42·39 per cent., as compared with 41·92 in March, an increase of 0·47 per cent. The mini-

mum percentage in the county is 65, and therefore the owners have to make up a deficiency of 22·61 per cent.

The Coal Trade.

The past month was a troublesome one for the Northern coal trade, but it had its compensations. While there were disputes with the putters, and stoppages of work and consequent interruptions in shipments, there was a good prompt trade for nearly all classes of coal, and prices, fixed and otherwise, were fully maintained. There are not many new buying orders circulating for April shipment, but the position in all descriptions is very steady. Fitters of every class report well-filled order books to the middle of the month and a fairly large amount of negotiations passing for the second half, and this gives confidence that prices will be maintained throughout the month, although there seems little prospect of any appreciation, as, if anything, competition both from other home centres and on the Continent is growing keener. Best Northumberland steams are steady for April at 13s. 6d. direct and 13s. 3d. to 13s. 4½d. second-hand, while Tyne primes move quietly at 12s. 9d. Best Durham steams command 15s. to 15s. 6d. for large, and 11s. 6d. for smalls. The gas coal trade position is favourable for two or three weeks ahead at 15s. to 15s. 3d. for best qualities, and 13s. 6d. to 13s. 9d. for secondary kinds. There is a steady demand for bunker descriptions, especially for first grades, which are firmly quoted at 14s. to 15s. 3d.; ordinary qualities steady at 13s. 3d. to 13s. 6d. Durham coking unscreened are quiet at 13s. 3d. to 13s. 9d. There is a moderate inquiry for gas coke for export, and a few orders have been placed at 20s., but additional business could be readily handled. Patent cokes are steady at 16s. 6d. to 17s. for good brands. Beehive coke is scarce at 24s. to 27s.

SCOTLAND.

(From our own Correspondent.)

Clyde Shipbuilding.

With the completion of the shipbuilding returns for March, the total for the first quarter of this year constitutes a record so far as tonnage is concerned. During March thirteen vessels of 46,138 tons aggregate were launched, bringing the first quarter's aggregate up to forty-one vessels of 162,897 tons aggregate. The number of vessels launched during the previous period has been exceeded on thirteen occasions since the year 1903, excluding the war years, but the nearest approach to the tonnage total was in 1921, when the first three months' aggregate was 149,841 tons. Unfortunately, however, it must again be noted that the returns give an erroneous idea of the state of the industry. While outputs are large fresh contracts are comparatively few in number, and the amount of work on the stocks has decreased considerably. The following vessels were included in the list of launches:—"Brunswick," 9200, oil tanker, for the Atlantic Refining Company, Philadelphia, U.S.A.; "Pacific Explorer," twin-screw motor ship, 6725 tons, for Furness, Withy and Co., London; "Vallejo," oil tanker, 5500 tons; "Elsa," motor tanker, 5400 tons, for Harry Borthen and Co., Oslo; "Antigone," cargo, 4550 tons, for the New Egypt and Levant Shipping Company, London; and the "Temple Bar," cargo, 4250 tons, for the Temple Steamship Company, Ltd., London. The only contracts reported during March were as follows:—A turbine steamer of 3000 tons for the Southern Railway Company's England to France service, and a passenger and cargo steamer of 1500 tons, for the Bombay Steam Navigation Company; a small tug for Belfast; and a shallow draught ferry boat for foreign owners.

Leith Shipbuilding.

It has been announced that Henry Robb, shipbuilder and repairer, Leith, is to take over the Leith shipbuilding yard of Cran and Somerville. Messrs. Robb have now decided to take over entirely the Glasgow firm of D. M. Cumming, Ltd., in which they have held a controlling interest, and to concentrate at Leith. Work formerly executed in the Glasgow works will in future be done in the yard of Cran and Somerville.

Steel.

Business in the steel market continues mostly of a hand-to-mouth character. No improvement is reported in the demand for plates and sections, and most works are in need of specifications. Black steel sheets, too, have rather a poor market at present, more especially for the heavier gauges, and galvanised descriptions are not particularly lively.

Iron.

Owing chiefly to the keenness of continental competition bar iron and re-rolled steel continue inactive. Prices for the latter are unchanged at £7 15s. per ton home and £7 per ton export.

Pig Iron.

Prices of pig iron remain firmer in view of the stronger ore position and the reduction in exports. At present thirty furnaces are in blast, eleven of which are making hematite, sixteen ordinary, and three basic.

Exports and Imports.

During the past week 8000 tons of iron ore and 1200 tons of steel and iron were discharged at Glasgow. Shipments of steel and iron products amounted to 4700 tons and pig iron shipments to 654 tons.

Coal.

The position in the coal trade is not improving. While the collieries' scheme to relieve the present depression in the industry has hardly been launched, there is already ample evidence that many pits will be closed down indefinitely, and application made for compensation under the scheme. The number to date is reported as twenty-seven pits, representing an output of some 70,000 tons per week. Meanwhile, owing to the advance of the season and to the fact that gas and electricity concerns and railway companies are already well contracted, the collieries find difficulty in securing the advance of 6d. per ton on fuel for home use, and the additional 1s. 6d. per ton on supplies to gas, electricity and railway companies, arranged for to provide compensation under the scheme. Prompt shipping business is almost of a hand-to-mouth variety, while forward transactions are almost at a deadlock owing to the disinclination on the part of shippers to discount current quotations. Best Fifeshire steams have stiffened a shade during the week, but practically all fuels are weakening, and the collieries find difficulty in checking the downward trend of prices.

WALES AND ADJOINING COUNTIES.

(From our own Correspondent.)

Coal Trade Conditions.

There is nothing like the pre-Easter holiday pressure in loading operations that at one time looked so likely. Shipments of steam coals are fairly good, but they cannot be described as active. The returns for the week ended the 30th ult. were much on the lines expected, and for the whole of the ports of South Wales the total came to 458,123 tons, which was a slight improvement upon the figures for the previous week, when the quantity was 438,864 tons. It is unlikely that the total for last week will be maintained in view of the holidays, and, furthermore, there does not appear to be the business about, while chartering operations of late have been rather disappointing. Shipments of anthracite coal may expand slightly this month in view of the commencement of shipments to Canada, but so far as steam coals are concerned, prompt orders are very scarce. Inquiries regarding supplies ahead are also on a rather restricted scale, but two of some importance comprise that for 30,000 tons of large coals for the Norte Railways of Spain for delivery during the next two months, while the other is from one of the leading Italian shipping undertakings for 60,000 tons of best Admiralty large coals for delivery over the next six months partly at Genoa and partly at Buenos Aires. In the case of the recent inquiry on behalf of the French Marine, it is reported that the authorities have only purchased about 25,000 tons of Admiralty large coals from this district, and that the balance of their requirements have been placed for French fuel.

Coal Stabilisation Scheme.

The position regarding the coal stabilisation scheme is somewhat nebulous. Naturally, in the absence of official reports as to the situation, rumours and reports of a more or less reliable character became current. Following upon meetings on Tuesday of last week of groups of colliery salesmen, it was discovered that salesmen of Monmouthshire qualities were quoting 3d. to 6d. above the prices previously acceptable, it being stated that the prices for these coals were not standing in proportion to the values of other descriptions. Nothing was said about the introduction of the scheme for the stabilisation of coals, and it was therefore assumed that an effort was being made to introduce the scheme piecemeal, which, however, scarcely appears to be a practical proposition, in view of the conditions of the scheme which involve the payment into a pool to recoup collieries which lose shifts. However, before the week was out, it was found that, as regarded Monmouthshire coals, salesmen were not adhering to the higher prices which they had suddenly quoted, and, following a meeting on Friday last of the Committee which has the scheme in hand, there was again no real development, the proceedings being adjourned to Monday last, although it was rumoured that, so far as superior large steam coals were concerned, minima prices were to be slightly above the figures now prevailing. All that has been made public as the result of the meeting of the Executive on Monday last is that the proceedings were again adjourned until Thursday in Easter week, so that the market must await developments until after the holidays.

Pulverised Fuel.

Cardiff docksmen listened with great interest to an address given to them on Friday last by Mr. David Wilson on the subject of "Pulverised Fuel, with special reference to South Wales." The directions, he said, in which powdered fuel were most likely to influence the coal trade were:—(1) Ability to burn efficiently any grade of coal; (2) ability to extract more heat units from the coal; (3) ability to obtain more work from boilers; (4) increased flexibility in the working of boilers; (5) cleanliness in the boiler-house; (6) better hygienic conditions for firemen. Summing up, Mr. Wilson said that there was good ground for believing that South Wales coals would become at least as popular as, if not more popular than, North Country coals for this method of firing, so that in the event of pulverised fuel predominating in the future, the prospects for the Welsh coal trade should be as rosy, if not more so, than in the past, both for inland and export. When Mr. Wilson discussed the outlook for marine purposes, his views were somewhat discouraging. In his opinion, he said, it will be a very long time before powdered fuel firing on board ship will reach a stage when it is likely to have any important influence on the South Wales coal trade. He pointed out that there were serious disadvantages in respect of the bunker space required, which would be 25 per cent. more than in the case of ordinary coal, while powdered bituminous coal could not be stored on board ship for more than two or three days without the danger of spontaneous combustion. That meant that pulverisation would have to be done on board, which would involve additional space for preparation plant, and consequently a diminution of cargo space, while there would be no gain as regards the time taken in bunkering.

Coal, Tin-plate and Steel Items.

One day's notice to terminate their employment was received by the workmen and officials, numbering about 2500, at the Universal collieries, Senghenydd, on Friday last. As the result of negotiations which have been proceeding for some time, the Tillery Colliery, belonging to the Ebbw Vale Company, is to resume operations after Easter. About 900 men will be employed. The colliery has been idle since October last. It was also arranged that work should restart at the Beynon Colliery, Blaina, on Monday last, when it was hoped that a very large percentage of the 1500 men previously employed would be taken on. Four new mills at the Old Castle Tin-plate Works, Llanelly, were expected to resume operations this week, thus bringing the number in commission up to ten. These mills were laid down about twelve months ago, but after working only a few weeks were rendered idle as the result of the slump in trade. It is also stated that in a few weeks' time three furnaces at Landore Steel Works will be relighted, which will provide work for about 250 men.

Dockworkers' Holidays.

Arrangements have been come to whereby trimmers and tippers work on Thursday, 5th inst., continuously from 7 a.m. to 10 p.m.—local arrangements to apply at Port Talbot, where work commences 8 a.m.—Saturday, 7th inst., work from 7 a.m. to 12 noon or to 1 p.m. to finish vessels; Tuesday, 10th inst., work from 7 a.m. to 12 noon; normal working hours being resumed on the following day.

Current Business.

Operations in coals of all descriptions have been quiet, and it is not expected that business will display any improvement until after the holidays. There is a feeling that to some extent business has been held up pending some definite news regarding the operation of the coal stabilisation scheme. Nominally, coal prices have not moved appreciably, and the position of many collieries is far from satisfactory from the point of view of a ready outlet for their supplies. At the end of last week there were forty-four idle loading appliances at the various docks in this district, but as the result of arrivals over the week-end this number was reduced to twenty-one, which, however, is not at all good.

Colliery Holidays.

It has been arranged that official holidays in the South Wales coalfield at Easter shall be two days, viz., Monday and Tuesday next, the night men to return to work on Tuesday night. The workmen's demonstration holiday has been fixed for May 7th.

CATALOGUES.

Tangyes Ltd., Birmingham.—A brochure illustrating some recent pumping plants installed.

Samuel Osborne and Co., Ltd., Sheffield.—Booklet illustrating castings and forgings for dredging plant.

F. Braby and Co., Ltd., Petershill-road, Glasgow.—Brochure describing in detail "Eclipse" pressed steel stairs.

Moore Drop Forging Company, Springfield, Mass., U.S.A.—Folder describing the "Morco" drop forged conveyor chains.

CONTRACTS.

The Bedford Engineering Company has received an order for a 35-ton electric crane for the Bedford Corporation Electricity Works.

Vickers-Armstrongs, Ltd., has received an order from the Bombay Port Trust for a ship-shape caisson for the communication passage between Princes and Victoria Docks, Bombay.

The Leeds Forge Company, Ltd., of Leeds, has received an order from the South African Railway Administration for one hundred drop-sided steel bogie wagons, each of 80,000 lb. capacity.

The Staveley Coal and Iron Company, Ltd., has recently received orders from thirteen separate customers for a total of over 4100 tons of cast iron pipes in sizes varying from 3in. to 24in. in diameter and in quantities varying from 120 to 1000 tons.

The Ateliers de Constructions Electriques de Charleroi, the London office of which is at 56, Victoria-street, Westminster, S.W. 1, has received from the Scheldt Intercommunal Electricity Company, of Antwerp, an order for two 40,000-kVA. 10,500-volt, 50-cycle, three-phase turbo-alternators.

The Hunslet Engine Company, Ltd., has just received an order from the London, Midland and Scottish Railway Company for a further batch of twenty-five tank locomotives, similar to those previously built. This is the fourth order received by the company from the L.M. and S. Rly. and will complete a total of ninety locomotives.

The British Thomson-Houston Company, Ltd., Rugby, has received an order from the Metropolitan Electric Tramways Company, Ltd., for 122 traction motors of 50 H.P. rating, and an order from the Dublin United Tramways Company, Ltd., for forty traction motors of 35 H.P. rating. These are repeat orders, the Metropolitan Tramways Company having ordered a total of 214 B.T.H. traction motors of the same type.

The Power-Gas Corporation, Ltd., of Stockton-on-Tees, has received an order from Synthetic Ammonia and Nitrates, Ltd., Billingham, for the fourth extension to the water gas and producer gas plant which it originally installed for this company. The order includes nine mechanical water gas generators with waste heat boiler equipment, auxiliaries and automatic control, also four mechanical producer gas generators with auxiliary equipment, together with the building for housing the plant and an overhead fuel bunker.

Automatic Telephone Manufacturing Company Annual Staff Dinner.—The staff of Automatic Telephone Manufacturing Company, Ltd., Strowger Works, Liverpool, held its fifth annual dinner on Friday, March 23rd, at the Exchange Hotel, the chair being occupied by Mr. John Lee, late Controller of the Central Telegraph Office, London. The toast of the evening, "The Company," was proposed by Sir Max Muspratt, Bart., Mr. John Lee responding. "Our Guests," proposed by Mr. G. W. Moore and acknowledged by Mr. Powell-Jones, Secretary of the Telephone Development Association, completed the toasts. An excellent concert followed.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
Native	19/- to 21/-
(1) Spanish	19/- to 21/-
(1) N. African	19/- to 21/-
N.E. Coast—	
Native	18/- to 21/-
Foreign (c.i.f.)	22/6

PIG IRON.

	Home. £ s. d	Export. £ s. d
(2) Scotland—		
Hematite	3 14 0	—
No. 1 Foundry	3 15 0 to 3 16 0	—
No. 3 Foundry	3 10 0 to 3 11 0	—
N.E. Coast—		
Hematite Mixed Nos.	3 10 0	3 10 0
No. 1	3 10 6	3 10 6
Cleveland—		
No. 1	3 8 6	3 8 6
Silicious Iron	3 8 6	3 8 6
No. 3 G.M.B.	3 6 0	3 6 0
No. 4 Foundry	3 5 0	3 5 0
No. 4 Forge	3 4 6	3 4 6
Mottled	3 4 0	3 4 0
White	3 4 0	3 4 0
Midlands—		
(3) Staffs.—		
All-mine (Cold Blast)	—	—
North Staffs. Forge	—	—
,, ,, Foundry	3 3 6	—
(3) Northampton—		
Foundry No. 3	2 19 0 to 3 0 0	—
Forge	2 14 0	—
(3) Derbyshire—		
No. 3 Foundry	3 4 0 to 3 4 6	—
Forge	2 19 0	—
(3) Lincolnshire—		
No. 3 Foundry	3 4 0	—
No. 4 Forge	3 3 6	—
Basic	3 2 6	—
(4) N.W. Coast— N. Lancs. and Cum.—		
Hematite Mixed Nos.	4 2 0 (a) / 4 5 0 (b) / 4 8 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d	Export. £ s. d
Scotland—		
Crown Bars	10 5 0	9 15 0
Best	—	— *
N.E. Coast—		
Iron Rivets	11 5 0	—
Common Bars	10 5 0	—
Best Bars	10 15 0	—
Lancs.—		
Crown Bars	10 0 0	—
Second Quality Bars	9 10 0	—
Hoops	13 0 0	—
S. Yorks.—		
Crown Bars	10 10 0	—
Best Bars	11 0 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	9 5 0 to 10 5 0	—
Marked Bars (Staffs.)	12 10 0	—
Nut and Bolt Bars	8 17 6 to 9 0 0	—
Gas Tube Strip	11 10 0	—

STEEL. (d)

	(6) Home. £ s. d	(7) Export. £ s. d
(5) Scotland—		
Boiler Plates	10 10 0	10 10 0
Ship Plates, ½in. and up	8 7 6	7 12 6
Sections	7 17 6	7 2 6
Steel Sheets, ¼in.	8 12 6	8 10 0
Sheets (Gal. Cor. 24 B.G.)	13 7 6	13 5 0

STEEL (continued).

	Home. £ s. d	Export. £ s. d
N.E. Coast—		
Ship Plates	8 7 6	—
Angles	7 17 6	—
Boiler Plates	12 15 0	—
Joists	7 17 6	—
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5
Hard Billets	7 12 6	—
Soft Billets	6 15 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	7 10 0 to 10 0 0	—
Manchester—		
Bars (Round)	8 17 6	—
,, (Small Round)	7 12 6	—
Hoops (Baling)	10 5 0	10 0 0
,, (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6	—
,, (Lancs. Boiler)	10 0 0	—
Sheffield—		
Siemens Acid Billets	10 0 0	—
Hard Basic	7 2 6 to 7 12 6	—
Intermediate Basic	7 0 0	—
Soft Basic	6 5 0	—
Hoops	9 10 0 to 10 10 0	—
Soft Wire Rods	7 10 0	—
Midlands—		
Small Rolled Bars	7 5 0 to 8 0 0	—
Billets and Sheet Bars	5 15 0 to 6 0 0	—
Sheets (20 W.G.)	11 10 0 to 12 0 0	—
Galv. Sheets, f.o.b. L'pool	13 2 6 to 13 5 0	—
Angles	7 17 6	—
Joists	7 17 6	—
Tees	8 17 6	—
Bridge and Tank Plates	8 12 6	—
Boiler Plates	11 0 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14	18/- to 18/3
Block Tin (cash)	239 15 0
,, (three months)	239 10 0
Copper (cash)	61 17 6
,, (three months)	61 17 6
Spanish Lead (cash)	20 5 0
,, (three months)	20 12 6
Spelter (cash)	24 18 9
,, (three months)	24 18 9
Manchester—	
Copper, Best Selected Ingots	66 0 0
,, Electrolytic	67 5 0
,, Strong Sheets	92 0 0
,, Tubes (Basis Price), lb.	0 1 1
Brass Tubes (Basis Price), lb.	0 1 0
,, Condenser, lb.	0 1 2
Lead, English	21 12 6
,, Foreign	20 12 6
Spelter	25 0 0
Aluminium (per ton)	£107

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	1/7½ per lb.	
Ferro Tungsten	1/3 per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£22 15 0	7/6
,, ,, 6 p.c. to 8 p.c. ,,	£22 7 6	7/-
,, ,, 8 p.c. to 10 p.c. ,,	£22 5 0	6/-
,, ,, Specially refined		
,, ,, Max. 2 p.c. carbon	£35 0 0	12/-
,, ,, ,, 1 p.c. carbon	£40 10 0	15/-
,, ,, ,, 0·70 p.c. carbon	£50 0 0	17/-
,, ,, ,, carbon free	1/2 per lb.	
Metallic Chromium	2/11 per lb.	
Ferro Manganese (per ton)	£13 10 0 for home; £13 10 0 for export	
,, Silicon, 45 p.c. to 50 p.c.	£12 17 6 scale 5/- per unit	
,, ,, 75 p.c.	£20 10 0 scale 6/- per unit	
,, Vanadium	14/3 per lb.	
,, Molybdenum	4/11 per lb.	
,, Titanium (carbon free)	0/11½ per lb.	
Nickel (per ton)	£170 to £175	
Ferro-Cobalt	9/6 per lb.	

FUELS.

SCOTLAND.

(Prices not stable.)

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	13/9
,, ,, Ell	14/6
,, ,, Splint	16/9 to 17/-
,, ,, Trebles	13/3
,, ,, Doubles	12/3
,, ,, Singles	11/3
Ayrshire—	
(f.o.b. Ports)—Steam	13/-
,, ,, Jewel	15/6
,, ,, Trebles	12/6 to 13/-
Fifeshire—	
(f.o.b. Methil or Burntisland)—Steam	10/6 to 12/6
Screened Navigation	18/-
Trebles	13/-
Doubles	12/6 to 13/-
Singles	11/6
Lothians—	
(f.o.b. Leith)—Best Steam	11/6
Secondary Steam	11/6
Trebles	12/6 to 13/-
Doubles	12/6
Singles	11/-

ENGLAND.

(8) N.W. Coast—	
Steams	24/- to 25/-
Household	37/6 to 50/-
Coke	22/6 to 23/6
Northumberland—	
Best Steams	13/6
Second Steams	11/9 to 12/-
Steam Smalls	9/-
Unscreened	11/9 to 12/-
Household	21/- to 27/-
Durham—	
Best Gas	15/- to 15/3
Second	13/3 to 13/9
Household	21/- to 27/-
Foundry Coke	17/6
Sheffield— Inland.	
Best Hand-picked Branch	27/6 to 29/6 —
Derbyshire Best Bright House	20/6 to 21/6 —
Best House Coal	19/- to 20/6 —
Screened House Coal	16/- to 17/6 —
,, ,, Nuts	15/- to 16/- —
Yorkshire Hards	14/6 to 15/6 —
Derbyshire Hards	14/- to 15/6 —
Rough Slacks	8/6 to 9/6 —
Nutty Slacks	6/- to 7/- —
Smalls	3/- to 4/6 —
Blast-furnace Coke (Inland)	13/- at ovens —
Furnace and Foundry Coke (Export), f.o.b.	17/- to 18/-

(9) SOUTH WALES.

Cardiff— Steam Coals:	
Best Smokeless Large	19/3 to 19/6
Second Smokeless Large	18/6 to 19/-
Best Dry Large	18/- to 18/6
Ordinary Dry Large	17/6 to 18/-
Best Black Vein Large	17/- to 17/3
Western Valley Large	16/6 to 16/9
Best Eastern Valley Large	16/6 to 17/-
Ordinary Eastern Valley Large	16/- to 16/3
Best Steam Smalls	12/6 to 13/-
Ordinary Smalls	11/- to 12/6
Washed Nuts	18/- to 23/-
No. 3 Rhondda Large	19/6 to 20/-
,, ,, Smalls	14/- to 14/9
No. 2 ,, Large	16/- to 16/6
,, ,, Through	14/6 to 15/6
,, ,, Smalls	12/6 to 13/6
Foundry Coke (export)	30/- to 37/6
Furnace Coke (export)	27/6 to 30/-
Patent Fuel	21/6 to 23/-
Pitwood (ex ship)	27/9 to 28/-
Swansea— Anthracite Coals:	
Best Big Vein Large	30/- to 32/6
Seconds	24/6 to 27/6
Red Vein	20/6 to 25/-
Machine-made Cobbles	38/- to 41/-
Nuts	37/6 to 42/6
Beans	23/- to 27/-
Peas	17/- to 18/-
Breaker Duff	8/- to 8/6
Rubbly Culm	9/6 to 10/-
Steam Coals:	
Large	17/6 to 18/6
Seconds	16/- to 17/-
Smalls	9/9 to 11/-
Cargo Through	15/- to 16/-

(1) Delivered. (2) Net Makers' works. (3) f.o.t. Makers' works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire.

(6) Home Prices—All delivered Glasgow Station. Boiler Plates 10/- extra delivered England. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (a) Delivered Glasgow. (b) Delivered Sheffield. (c) Delivered Birmingham. (d) Rebate 12/6 joists and 10/- all other materials if home consumers confine purchases solely to British products.

French Engineering Notes.

(From our Correspondent in Paris.)

The Trade Outlook.

In a general way the iron, steel and engineering trades maintain the slightly increased activity that was imparted to them by the formation of the comptoirs when consumers purchased more largely in anticipation of higher prices and the railway companies and State administrations gave out a fair number of orders for locomotives, wagons and other material. There is, however, no evidence of that activity accentuating, and a feeling is prevalent that the expectations of a recovery have not been fully justified. There was bound to be a slackening of industrial enterprise on the eve of the general elections, and it is hardly likely that any recovery can take place until something definite is known of the early future. Even then, the probability of a notable improvement appears remote, for the reason that the elements of trade activity are more or less artificial, and the reluctance of capital to engage in industrial enterprise of any kind prevents the carrying out of works of public utility, except with the aid of material supplied by Germany on account of reparations. An official statement has been published giving the nature and value of the material which is to be obtained from Germany for the carrying out of works at home and in the Colonies, and it conveys an impression that there is likely to be considerable activity in the early future, but that obviously depends upon the readiness with which Germany will supply the material. There is, moreover, a good deal of uneasiness over German competition, as evidenced by the increasing exports of iron and steel from that country, while the consignments of German machinery abroad were never so large as they are now. Furthermore, the German Government has again set apart this year a sum of 175 million marks for the development of foreign trade. The French steel production is so much in excess of home requirements that markets must be found for bars and sheets and other products, and as the consumption appears to have declined in other producing countries, there are possibilities of competition which can only be checked by the operation of the Steel Union.

Competition Abroad.

A normal industrial activity at home would absorb the bulk of the French production and leave producers in a good position to dispose of a surplus output abroad, but the higher prices due to the operations of the new comptoirs, while stimulating buying temporarily, have again checked the demand, although the more remunerative prices obtained at home for steel and steel products are enabling makers to compete more successfully for business abroad. At the same time, the increased values of iron and steel on the French market have enhanced production costs in the constructive and mechanical engineering industries, and those factors are observable in the returns of foreign trade during the first two months of the year. There was an increase in the quantity of steel and other products "necessary for industry" exported, and a decline in values, while the exports of manufactured goods underwent a decline both in tonnage and in value. The value of imports during the first two months of the year was 8444 million francs, a declension of 357 million francs as compared with the similar period of 1927, and the value of exports totalled 8440 million francs, a contraction of 834 million francs. As regards quantities, the imports totalled 7,171,844 tons, or 1,647,945 tons less than in the first two months of last year, and the exports amounted to 6,590,836 tons, an increase of 592,011 tons. While the imports of "material necessary for industry" declined by 1,269,809 tons, there was an augmentation in value of more than 58 million francs, and a reduction of 13,422 tons in the imports of manufactured goods was accompanied by an increase in value of no less than 224,579,000 francs. On the other hand, there was an augmentation of 358,379 tons in the exports of "material necessary for industry," and a decline in value of 638,506,000 francs. The exports of manufactured goods declined by 67,858 tons, and the value underwent a contraction of no less than 465,746,000 francs.

Displacing a Bridge.

A vast programme of port extensions is being carried out at Strasburg with the object of enabling that town to compete successfully with Kehl, on the other side of the Rhine, for the water-borne traffic, which, it is expected, will grow considerably in the future when the French programme of inland waterway development is completed. In carrying out those works the road between Strasburg and Kehl had to be reconstructed at a distance of 310 m. from the old route, and the existing bridge over the short arm of the Rhine had to be removed to the new position. The arch of the bridge from which the roadway is suspended is of box girder design, with large sections at the ends and a small section in the centre. The weight of the bridge is 1050 tons. The operation is the more difficult because the river at this point describes a curve with an inside radius of 100 m. Rail tracks were constructed along the banks on which rested the ends of the bridge. It was moved along successfully by hydraulic jacks to the new position.

Destroyers.

At Lorient there will be launched in a few days the destroyer Guépard, which is the first of a new class of vessels with increased cruising range and powerful armament. Having a displacement of 2690 tons, its length is 130 m. and width 11·50 m. It will be fitted with turbines developing 70,000 horse-power. It is designed for a speed of not less than 36 knots. The armament will consist of five 138 mm. guns and four anti-aircraft guns, as well as four Thornycroft depth charge throwers. Two similar vessels are under construction, the Bison at Lorient and the Lion at Dunkirk, and three others are being put on the stocks. As is the case with the submarines, the object of the programme of naval construction is to standardise a type of powerful and fast destroyer in order to build the vessels cheaply in the shortest time.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C., at 1s. each.

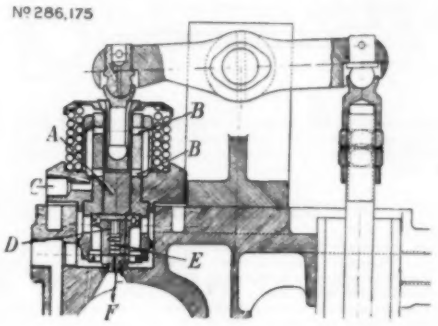
The date first given is the date of application; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

286,175. September 26th, 1927.—FUEL NOZZLES, Christoph und Unmack Aktiengesellschaft, Niesky, Oberlausitz, Germany.

In this nozzle a mixture of fuel and air is compressed previously to being admitted to the combustion space to such an extent that the temperature of compression vaporises the fuel. This

Nº 286,175



compression is effected by the piston A, into the cylinder of which air is admitted by the ports B B, while the fuel enters at C. When the pressure is sufficient to overcome the resistance of the spring D the valve E opens and the mixture is injected into the combustion space through the jet F. A feature of the arrangement is the system of assembly, which enables the various parts to be taken apart quickly for cleaning.—*March 1st*, 1928.

DYNAMOS AND MOTORS.

274,486. July 14th, 1927.—IMPROVEMENTS IN OR RELATING TO CLOSED CIRCULATING COOLING SYSTEMS WITH EXTERNAL VENTILATING MEANS FOR ELECTRIC MACHINES, Aktiengesellschaft Brown, Boveri & Cie., of Baden, Switzerland.

The fan casing A with the fan wheel B are mounted directly above the casing C of the electric machine. The coolers D are

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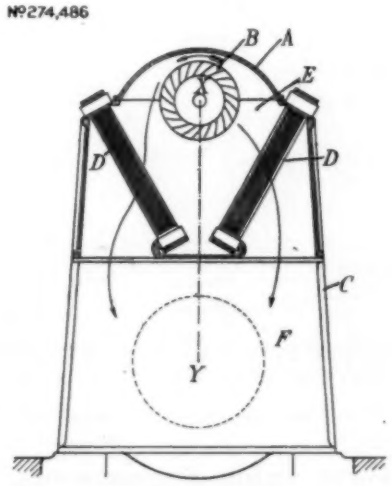

mounted in "V" formation in the delivery space E of the fan, and so that the point of the "V" rests on the connecting line X Y of the fan shaft and the shaft of the electric machine. The heated air from the machine enters the centre of the fan and circulates through the coolers D to the internal space F of the electric machine and back again to the centre of the fan, in a plane parallel to that of the drawing.—*February 23rd*, 1928.

TRANSFORMERS AND CONVERTERS.

275,643. August 5th, 1927.—IMPROVEMENTS IN OR RELATING TO ELECTRICAL PHASE AND FREQUENCY CHANGERS, *International General Electric Company, Incorporated, of 120, Broadway, New York, U.S.A.*

This specification describes an arrangement for changing three-

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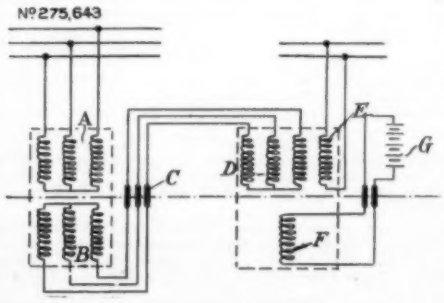
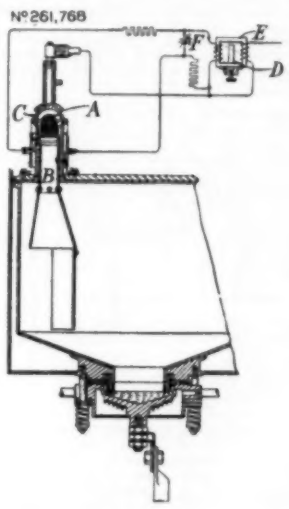


phase current at one frequency into single-phase current at another frequency. The stator winding A of an asynchronous motor is connected to the three-phase network, whilst the rotor winding B is connected across the slip rings C of a synchronous machine mounted on the same shaft. On the stator of the synchronous machine there is an additional single-phase winding E which is connected to the single-phase network. F is the rotor winding of the synchronous generator and it is fed by a direct-current source G. If it is required to convert 3000 kW 50 periods current into single-phase current of 16⅔ periods this would give the following distribution of energy with a four-pole construction of the asynchronous machine and a two-pole construction of the synchronous generator and a speed of 1000 r.p.m. Of the 3000 kW, 1000 kW is transmitted electrically and 2000 kW mechanically to the rotor of the asynchronous machine. The electrical slip output, which shows a frequency of 16⅔ per second, is conveyed across the slip rings C to the stator winding D and is thence transmitted electrically to the single-phase winding E. The mechanical output of 2000 kW is generated in the single-phase winding E by the generative operation of the synchronous machine and conveyed to the single-phase network. The synchronous machine therefore represents on the one hand a multiphase single-phase converter, and on the other hand a single-phase synchronous generator. For the damping of the internal rotating field of double frequency it is advisable to provide a damping winding on the rotor of the asynchronous machine.—*February 23rd*, 1928.

261,768. November 19th, 1926.—IMPROVEMENTS IN OR RELATING TO VAPOUR ELECTRIC RECTIFIERS, *The British Thomson-Houston Company, Ltd., of Crown House, Aldwych, London, W.C. 2.*

In the operation of mercury vapour rectifiers, current is transmitted between a positively charged anode and the cathode through an electric arc, which carries a multitude of positive ions. The presence of positive ions in the vicinity of the anode is desirable when it is positively charged, and is transmitting current because these ions reduce the space charge and facilitate the transmission of current through the device. When the anode is charged to a negative polarity, and is not transmitting current, however, the presence of positive ions in the vicinity of the anode is undesirable for the reason that they are attracted to the anode and tend to raise its temperature to a point at which electrons are emitted. These electrons ionise the surrounding vapour, thus producing more positive ions and establish-

Nº 261,768



ing a condition likely to lead to the formation of destructive arcs, commonly denoted by the expression "arc back," between the negatively charged anode and some other part of the device. According to the invention, the rectifier has an intermediate electrode A, termed the grid or control electrode, interposed between an anode and other intermediate electrode B, called the shield, and these auxiliary electrodes are energised with separate periodic voltages, which bear some definite relation to the anode voltage. The phase relation between the voltage of the anode C and the grid or control electrode A is dependent on the adjustment of the movable core member D of the reactance device E, and the phase relation between the voltages of the control electrode A and the shield B is determined by the adjustment of the condenser F. The manner in which the phase relation between the anode control electrode and shield voltages is utilised to prevent "arc back," due to the presence of positive ions within the shield when the anode assumes a negative polarity is fully explained.—*February 20th*, 1928.

284,306. June 20th, 1927.—IMPROVEMENTS IN OR RELATING TO RECTIFYING INSTALLATIONS FOR ALTERNATING CURRENT, N. V. Philips' Gloeilampenfabrieken, of Emmasingel 6, Eindhoven, Holland.

According to this invention, a rectifier is provided with separate output terminals connected so that the current obtained from the rectifier may be supplied either by both half waves of the alternating current or by one of them. In the diagram, A is the main transformer and B the rectifier. The anodes C and D

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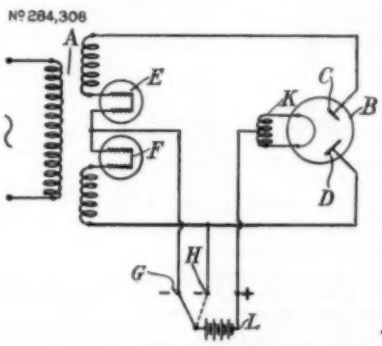
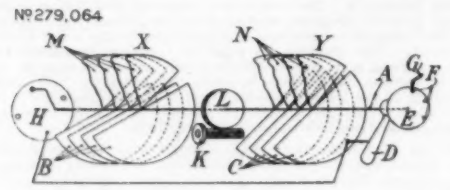


are connected to variable resistances E and F, and to the negative direct-current terminals G and H. The middle point of the coil K is connected to the positive direct-current terminal L, the coil K being a transformer coil. It will be seen that by connecting the negative terminal of the battery to terminals H or G, full-wave or half-wave rectification can be obtained. If a higher charging voltage than that obtainable with full-wave rectification is desired, only one half of the alternating current supply will be used and half-wave rectification will be employed.—*February 23rd*, 1928.

TELEGRAPHS AND TELEPHONES.

279,064. October 3rd, 1927.—IMPROVEMENTS IN RADIO RECEIVERS OF THE SUPERHETERODYNE TYPE, Lucien Levy, of 66, rue de l'Université, Paris, France.

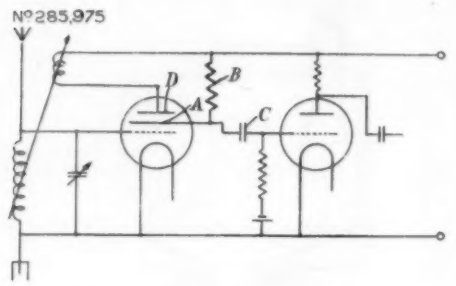
This specification describes a device for simultaneously tuning the receiving and heterodyne circuits of a superheterodyne wireless set adapted to operate on several ranges of frequency. Two condenser rotors are mounted on the same spindle A. The stator B of the condenser X remains stationary, whereas the stator C of the condenser Y may move round the common axis A by means of a handle D mounted loosely on the spindle. The



handle is secured to a disc E with notches F for the reception of a spring G. A switch H gives the induction coils in the aerial and heterodyne circuits the values required for the different ranges of wave lengths and is also controlled by the handle D. It is therefore an easy matter to pass from one range to another, the required modification of the angular setting of the condenser being provided simultaneously with the operation of the switch. To finish the adjustment within a given range it is sufficient to rotate the two rotors M N together through a worm K meshing with a worm wheel L keyed to the spindle.—*March 1st*, 1928.

285,975. November 23rd, 1926.—IMPROVEMENTS IN OR RELATING TO THERMIONIC VALVES, The Edison Swan Electric Company, Ltd., of 123–125, Queen Victoria-street, London, E.C. 4, and Thomas Willis Price, of 14, Westfields-road, Acton, W. 3.

This specification describes a thermionic valve having two anodes A and D for the purpose of varying the electrical characteristics. The main anode A is connected through a resistance

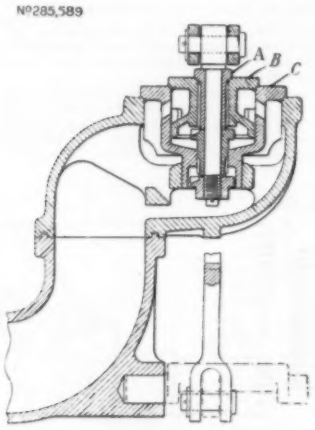


B of about 5 megohms to the positive terminal of the high-tension supply and through a condenser C to the grid of the second valve. The second anode D is connected through a reaction coil to the positive pole of the high-tension supply. With this arrangement it is possible to employ a valve having a high amplification factor, and a high impedance in conjunction with a high anode resistance, and at the same time with the aid of the additional anode to obtain reaction. There are four other illustrations.—*February 23rd*, 1928.

LOCOMOTIVES.

285,589. November 24th, 1926.—STEAM REGULATOR VALVES, J. Mitchell, 69, Kenilworth-court, Putney, London, S.W. 15, and J. C. G. Cossey, Calbourne, The Vale, Golders Green, London, N.W. 11.

This invention relates to valves of the multiple-beat type and more particularly to steam regulator valves, the main objects in the invention being the provision of a valve having a large inlet opening, with valve members having short lifts from their respective seats, which members are easily operated against

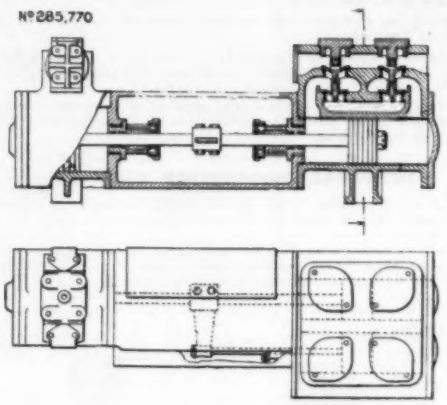


high pressures, and in which valve leakage, owing to unequal expansion of the valve members and valve casing, is eliminated. These objects are attained by arranging a plurality of valves concentrically one within the other and preferably by employing not less than three of such valves. The three valves are shown at A, B, and C, and are opened in succession. As each valve is opened it admits steam to put the next valve in a state of equilibrium.—*February 23rd*, 1928.

PUMPING AND BLOWING MACHINERY.

285,770. November 7th, 1927.—FEED-WATER PUMPS, Société Françaises des Pompes et Machines Worthington, 1, rue des Italiens, Paris.

This pump is intended for feeding locomotive boilers in connection with a heater in which the cold feed is mixed with exhaust steam. The pump comprises two water barrels and one steam cylinder. One of the pumps delivers the cold water to the heater and the other takes the hot water and forces it into the boiler. The cold pump does not have much work to do, so it is driven

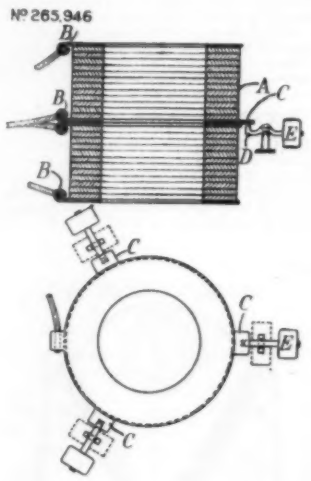


by a crosshead bolted on to the side of the piston-rod; but as the hot pump has much more resistance to overcome, it is in line with the steam cylinder, and is driven directly.—*February 23rd*, 1928.

MISCELLANEOUS.

265,946. January 21st, 1927.—IMPROVEMENTS IN OR RELATING TO CARBON RESISTANCES, Naamlooze Vennootschap Machinerieen en Apparaten Fabrieken, Croeselaan 24, Utrecht, Holland.

A resistance made in accordance with this invention consists of carbon discs A and metal rings B. At the centre there are two metal rings, the upper rings having projections C. Under each



of these projections there is a lever D, carrying a small weight E. The weights nearly counterbalance the pressure between the rings in the centre of the resistance. The error in the voltage regulation caused by expansion under heat is said to be considerably less than usual. The top and bottom metal plates are connected in parallel and the current is supplied to the leads from these plates and to the lead that is connected with the centre plate.—*February 28th*, 1928.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Wednesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY TO MONDAY, APRIL 9TH.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Southern District meeting in Guernsey.

TUESDAY, APRIL 10TH.

INSTITUTE OF MARINE ENGINEERS.—85–88, The Minories, Tower-hill, London, E. 1. "The Practical Value of the Report of the Heat Engine and Boiler Trials Committee," by Mr. G. J. Wells. 6.30 p.m.

WEDNESDAY, APRIL 11TH.

INSTITUTION OF ENGINEERS-IN-CHARGE.—St. Bride Institute, Bride-lane, Fleet-street, London, E.C. 4. "Modern Welding Processes," by Mr. E. F. Newall and Mr. W. E. Quine. 7.30 p.m.

THURSDAY, APRIL 12TH.

ROYAL AERONAUTICAL SOCIETY.—At the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "The Variable Pitch Airscrew," by Dr. Hele-Shaw and Mr. T. E. Beacham. 6.30 p.m.

THE INSTITUTE OF METALS: LONDON LOCAL SECTION.—In the Rooms of the Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W. 1. Annual general meeting. "Alchemists in Art and Literature," by Mr. R. B. Pilcher. 7.30 p.m.

FRIDAY, APRIL 13TH.

INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—Visit of the West Midland District to the bridge over the Severn, Holt Fleet, near Droitwich. 3 p.m.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. "Calculating Apparatus and Diagrams for Engineers," by Mr. A. P. Morris. 7.30 p.m.

THE INSTITUTION OF ENGINEERING INSPECTION.—At the Rooms of the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. "Low-temperature Carbonisation," illustrated by lantern slides, by Mr. R. P. Wilson, in collaboration with Mr. C. H. Parker. 7.30 p.m.

FRIDAY AND SATURDAY, APRIL 13TH AND 14TH.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS.—East Midland District Meeting at Skegness.

MONDAY, APRIL 16TH.

RAILWAY CLUB.—25, Tothill-street, London, S.W. 1. "South American Railways," by Mr. B. M. Bazley. 7.30 p.m.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. Dr. Mann Lecture, "Applied Architectural Acoustics," Lecture 1, by Mr. A. G. Huntley. 8 p.m.

WEDNESDAY, APRIL 18TH.

ROYAL SOCIETY OF ARTS.—John-street, Adelphi, London, W.C. 2. "American Architecture," by Mr. A. C. Bossom. 8 p.m.

THE INSTITUTE OF METALS: SWANSEA LOCAL SECTION.—In the Thomas Café, High-street, Swansea. Annual general meeting. 7 p.m.

THURSDAY, APRIL 19TH.

INSTITUTION OF ELECTRICAL ENGINEERS.—Savoy-place, Victoria Embankment, London, W.C. 2. The Nineteenth Kelvin Lecture, "Recent Advances in Physics," by Sir Oliver Lodge. 6 p.m.

THE INSTITUTION OF CIVIL ENGINEERS: BIRMINGHAM AND DISTRICT ASSOCIATION.—Prince's Chambers, 6, Corporation-street, Birmingham. Annual general meeting. "The Sandfields Filters of the South Staffordshire Waterworks Company," by Mr. R. A. Robertson.

FRIDAY, APRIL 20TH.

JUNIOR INSTITUTION OF ENGINEERS.—39, Victoria-street, London, S.W. 1. "An Outline of the Distribution of Petroleum," by Mr. W. M. Hurrell. Discussion and re-exhibition of slides. 7.30 p.m.

WEDNESDAY, APRIL 25TH.

NEWCOMEN SOCIETY.—Prince Henry's Room, 17, Fleet-street, E.C. 4. "Steamers of Lake Champlain, 1809 to Present Day," by Mr. L. F. Loree. 5.30 p.m.

THURSDAY, APRIL 26TH.

JUNIOR INSTITUTION OF ENGINEERS.—Monico Restaurant, Piccadilly-circus, W. 1. Annual dinner. 6.30 p.m.

FRIDAY, APRIL 27TH.

INSTITUTION OF ENGINEERS-IN-CHARGE.—Venetian Chamber, Holborn Restaurant, London. Annual dinner. 6 p.m. for 6.30 p.m.

THURSDAY, MAY 3RD.

IRON AND STEEL INSTITUTE.—Connaught Rooms, Great Queen-street, London, W.C. 2. Annual dinner. 7 for 7.30 p.m.

THURSDAY AND FRIDAY, MAY 3RD AND 4TH.

IRON AND STEEL INSTITUTE.—At the house of the Institution of Civil Engineers, Great George-street, London, S.W. 1. Annual meeting.

TUESDAY, MAY 8TH.

THE INSTITUTE OF METALS.—The Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Eighteenth annual May lecture, "The Chemical Properties of Crystals," by Professor Cecil H. Desch, F.R.S. 8 p.m.

WEDNESDAY, MAY 16TH.

ROYAL METAL TRADES PENSION AND BENEVOLENT SOCIETY.—Second annual golf competition at Sundridge Park Golf Club, Bromley, Kent.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

JOHN HETHERINGTON AND SONS, Ltd., of Manchester, ask us to announce that they are not included in the recently formed heavy machine tool combine.

WALWORTH LTD., of 90-96, Union-street, Southwark, London, S.E. 1, asks us to announce that it has opened a house at 26, Bridge-street, Deansgate, Manchester. Telegrams, "Walworthey, Manchester;" telephone, Central 5633. Mr. G. Stan Arthur is the manager in charge.

THE Council of the Institution of Mining and Metallurgy has accepted an invitation received from the Cornish Institute of Engineers and four other representative Cornish bodies to hold a meeting of the Institution of Mining and Metallurgy in Cornwall during the week commencing May 21st next.

HACKSAW BLADE.—We have received from James Neill and Co. (Sheffield), Ltd., Composite Steel Works, Napier-street, Sheffield, a sample hack-sawing machine blade, made of high-speed steel, and known as the "Eclipse." These blades are, of course, more expensive than the ordinary low-tungsten blades, but it is claimed for them that they will cut twice as quickly and do at least five to seven times the amount of work. We have not been able to verify these figures ourselves but we understand that the makers are quite ready to send sample blades to manufacturing engineers so that they may satisfy themselves that the enhanced price, which is three and a-half to four times that of ordinary blades, is worth while.

GLIDER SLIDE RULE.—The "Glider" slide rule is made by John Davis and Son (Derby), Ltd., of All Saints Works, Derby, who have sent us one of their latest models. The general features of the design are probably familiar to many of our readers, but for those not acquainted with them we may say that the outstanding characteristic is a slot which runs nearly the whole length of the slide. The sides of the slide are sprung outwards slightly by a wavy spring placed in this slot, with the result that the slide maintains a pleasant fit, even after long periods of work under trying conditions. Furthermore, the two outer scales are joined by a metal back, and in the event of the fit becoming too loose, it is only necessary to withdraw the slide and press the sides towards each other. The slide has a very easy, but steady movement, and the annoying looseness at the ends which is sometimes experienced is quite obviated by the spring slide. A small but useful detail is the narrowing of the slide at the ends, so that it is very easy to return to its position after it has been withdrawn. The example before us has on the front, besides the ordinary scales, an "F" scale for cubes and cube roots and an "E" scale evenly divided. On the back of the slide there are the usual sine and tangent scales.